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# THE Britiſh MARINER'S GUIDE.

CONTAINING,

Complete and Eaſy Inſtructions

FOR THE

Diſcovery of the LONGITUDE at Sea and Land, within a Degree, by Obſervations of the Diſtance of the Moon from the Sun and Stars, taken with HADLEY'S Quadrant.

To which are added,

An APPENDIX, containing a Variety of intereſting Rules and Directions, tending to the Improvement of Practical Navigation in general.

And a Sett of correct

ASTRONOMICAL TABLES.

12 D 8

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M DCC LXIII.

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MVSEVM
BRITAN
NICVM

TO

THE RIGHT HONOURABLE

The LORDS COMMISSIONERS

For Executing

The Office of LORD HIGH ADMIRAL of GREAT
BRITAIN and IRELAND,

This TREATISE,

Deſigned for the Benefit of the Britiſh Navigation,

Is moſt humbly Inſcribed,

MVSEVM
BRITAN
NICVM

BY

Their LORDSHIP'S

Very Obedient,

And Devoted

Humble Servant,

NEVIL MASKELYNE.

# PREFACE.

EVERY attempt towards the clearer aſcertainment of the Longitude at ſea will readily be acknowledged as a point of great importance and utility to a maritime and commercial nation. Daily experience ſhews the wide uncertainty of a ſhip's place, as inferred from the common methods of keeping a reckoning, even in the hands of the ableſt and moſt careful navigators. Five, ten, or even fifteen degrees, are errors which no one can be ſure he may not fall into in the courſe of long voyages. The water is ſo fluid an element, and ſo eaſily put in motion by the force of the wind, or the action of the ſun and moon upon it, and theſe motions are ſo readily propagated to great diſtances, that it is not to be wondered at, that hitherto no means have been found out of allowing for the effects of ſuch variable and irregular cauſes.

During the courſe of my voyage to and from St. Helena, I made frequent obſervations of the diſtance of the moon from the ſun and fixed ſtars, in order to determine our longitude; and can from ſuch experience venture to anſwer, that this method, carried into practice, will, (without diſparagement to the labours and inventions of others) bring the longitude to great nearneſs.

I here preſent to the public the precepts neceſſary to be followed, whether in making the obſervations, or the calculations; being for the moſt part ſuch as I have practiſed myſelf: and they will, I hope, be found much more eaſy and conciſe than any yet propoſed. In particular, I flatter myſelf, that my two rules for clearing the obſervations of the effects of refraction and parallax, will appear to reduce to great ſimplicity that part of the computation, which was before the moſt tedious and perplexed.

In order that I may not leave the diligent mariner in want of any thing eſſential to his computations, I have added correct tables of the ſun and moon. The lunar equations are taken from the late Mr. Mayer's printed tables, which I have reaſon to think, applied to careful obſervations, will determine the longitude always within about a degree, and generally within half a degree. The reader will alſo find here many other tables, uſeful on this, as well as on many other occaſions, which might not eaſily be procured elſewhere; particularly, a copious table of the longitudes of places determined from aſtronomical obſervations, or inferred by their bearings and diſtances from neighbouring places ſo determined; many of which are deduced from the obſervations of the late tranſit of the planet Venus over the ſun, or from obſervations made on that occaſion; to which are added their latitudes. The longitudes are reckoned from the meridian of the Royal Obſervatory at Greenwich, which is only five minutes thirty-ſeven ſeconds of longitude to the eaſt of St. Paul's Church in London. The tables of the ſun and moon are likewiſe adapted to the ſame meridian; and the two examples of the calculation of the longitude, the one diſperſed through the book, as an example of the ſeveral rules, and the other placed entire towards the end of the Appendix, are therefore made from the ſame meridian.

Having compriſed in ſeven Chapters the general proceſs for finding the longitude by obſervations

ſervations of the moon, I thought it would be of ſervice to add an Appendix, containing a variety of intereſting rules and directions, uſeful in particular caſes, or tending to the improvement of practical navigation in other branches. A deſire of making the treatiſe more complete hath led me to the extenſion of the latter part of it beyond the limits I at firſt propoſed; but ſhould that extenſion give it greater utility, as I flatter myſelf it will, I ſhall not think my pains miſemployed about it, nor my reader, I hope, deem it ſuperfluous. In particular, I conceive, that the Problem propoſed and explained in page 61, for finding the longitude from three cotemporary obſervations only, which is new, may on many occaſions be of great uſe.

I foreſee but one material objection that can be made to the uſefulneſs of this method of finding the longitude at ſea, namely, the difficulty and nicety of the calculations. But then I flatter myſelf, that the rules I have laid down, demanding only care in the computer, and requiring no particular knowledge of ſpherical trigonometry, or the projection of the ſphere, as moſt of the methods which have been formerly propoſed do, will, in a great meaſure, obviate this objection. However, I own, it is rather to be wiſhed, that ſuch parts of the computations as conveniently can, were made previouſly at land by capable perſons, and publiſhed, from time to time, for the common benefit of navigation; eſpecially, as not only the much greater, but alſo the niceſt part of the calculations is of this kind: for if the moon's longitude and latitude were but computed for every twelve hours in the year, and thence her diſtance from the ſun, or a proper ſtar on each ſide of her, was calculated carefully for every ſix hours, and the computations publiſhed a convenient ſpace of time before-hand, I do not ſee why the longitude might not be as univerſally found at ſea by this method, as the latitude is at preſent.

Since the book has been printed off, I find I have omitted two particulars, the obſervance of which will conduce to the more accurate determination of the longitude; the one reſpecting the obſervations, and the other the calculations, which I ſhall here deliver, and deſire the reader will pay a proper regard to.

I have mentioned, in the ſecond Chapter, the neceſſity of giving a ſweep with the quadrant, ſo as to make the ſtar ſeem to deſcribe a tangent line to the moon's limb; but forgot in the ſame place to add the neceſſity of obſerving this contact as near the middle of the teleſcope, or field of view, as poſſible, which is as eſſential a circumſtance as the other; for, unleſs a ſweep be given with the quadrant, the diſtance of the ſtar may be taken from ſuch a part of the moon's limb as is neither the neareſt nor remoteſt; and if the contact be not obſerved near the middle of the field of view, the rays by which the moon and ſtar are ſeen, will not paſs parallel to the plane of the inſtrument, and conſequently the angle meaſured will not be exact.

The other particular, of which I deſire to advertiſe the reader, reſpecting the calculations, is a ſecond ſmall correction neceſſary to be made to the obſerved diſtance of the moon's limb from the ſun or a ſtar on account of parallax.

In the rule delivered in Chap. V. for the correction of parallax, which is deduced from the fluxions of the ſpherical triangle, formed between the zenith, the moon, and the ſun or ſtar, as well as in moſt other methods that have been propoſed for this purpoſe, the perpendicular dropt from the apparent place of the moon upon the great circle joining the true places of the moon and ſun, or ſtar, is taken inſtead of the ſmall arch of a parallel circle, deſcribed from the ſun or ſtar as a pole. This rule therefore may ſometimes err a minute, if the diſtance of the moon from the ſun or ſtar be thirty degrees, and more, if the diſtance be leſs; but is eaſily corrected as follows.

Call the principal effect of parallax, found by Chap. V. the parallax in diſtance; and with the moon's apparent altitude, and horiſontal parallax, take the parallax in altitude out of the Table, page 26. Then, to the conſtant logarithm 0.941 add the logarithm of the ſum of the parallaxes in altitude and diſtance, the logarithm of the difference of the ſame parallaxes, and the cotangent of the apparent diſtance of the ſtar from the moon's centre; the ſum, deducting 13 from the index, is the logarithm of the number of ſeconds required, being the ſecond correction of parallax, and is always to be added to the diſtance of the ſtar from the moon's limb, firſt corrected for refraction, and the principal effect of refraction, as by Chap. V.

except the diſtance exceeds 90 degrees, in which caſe it is to be ſubſtracted.

In the example diſperſed through the book, by way of illuſtration of the rules, the apparent diſtance of the ſtar from the moon's centre was 51d. 30m. the parallax in diſtance was found 20½m. in Chap. V. and the moon's horiſontal parallax being 56¼ m. and her apparent altitude 12d. 26m. the parallax in altitude, by the table, page 26. is 55 m.

| | | | |
|---|---|---|---|
| Conſtant logarithm | — | — | 0.941 |
| Sum of par. in alt. and diſt. | 55′+20′=75 | logarithm | 1.875 |
| Diff. of par. in alt. and diſt. | 55′—20′=35 | logarithm | 1.544 |
| App. diſt. of ſtar from moon's centre | 51d. 30m. | cotang. | 9.900 |
| Sum, abating 13 from the index, is | | — | 1.260 |

The logarithm of 18ſ. the ſecond correction of parallax, which, added to 51d. 9m. 32ſ. the true diſtance of the ſtar from the moon's centre, cleared of refraction, and the principal effect of parallax, at the bottom of page 43, gives 51d. 9m. 50ſ. the true and abſolute diſtance of the ſtar from the moon's centre. If the computation in Chap. VI. be repeated with this diſtance correct, the difference of the moon and ſtar's longitudes will come out 18 ſ. greater than was found in page 48, or 51d. 12 m. 23 ſ. whence the longitude of the moon inferred from obſervation ſhould be 8 S. 11d. 44 m. 13 ſ. and the difference between this longitude and that computed from the tables, ſee Chap. VII. will be 47 ſ. which, multiplied by $28\frac{1}{10}$, gives 1321 ſeconds, or 22 minutes, by which the ſhip is weſt of the account.

I have applied this correction to the obſervations made in my voyage home from St. Helena to England, though it has in none of them exceeded half a minute; the reaſon of which is, that I never took the diſtances of the moon from ſtars under 25 or 30d. but rather choſe them at the greateſt diſtances, even up to 90d.

In my voyage out this correction was leſs neceſſary, moſt of the obſervations being made either about or under the latitude of 30 degrees, where the ſtars riſing and falling more nearly perpendicular, than in higher latitudes, the angle of poſition at the moon, contained between the two great circles paſſing from thence, one thro' the ſtar, and the other thro' the zenith, will be ſmaller, and conſequently the correction in queſtion, being as the ſquare of the ſine of that angle, will be ſmaller alſo.

In ſtrictneſs, a ſecond correction ought to be applied on account of refraction, as well as of parallax; but as this can only be neceſſary when the moon or ſtar are very near the horiſon, namely under three degrees of altitude, and the obſervations ought never to be taken ſo low, on account of the variability and irregularity of the refraction itſelf, this correction may be ſafely omitted, as of little conſequence in practice.

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# THE
# BRITISH MARINER'S Inſtructions
# For FINDING the
# LONGITUDE
# BY SEA AND LAND.

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## CHAP. I.

### *Of the* INSTRUMENTS *neceſſary to be uſed in making the Obſervations.*

ALL the inſtruments neceſſary for determining the longitude by obſervations of the moon, are a Hadley's quadrant, and a tolerably good watch. The quadrant ſhould be of about eighteen inches radius, and, if not made all of braſs, ſhould be framed of well-ſeaſoned wood, with a braſs arch and index. The Vernier's ſcale muſt be made to carry the ſubdiviſions to ſingle minutes; and the eye may itſelf ſubdivide ſtill nearer to a fraction of a minute, eſpecially if aſſiſted with a magnifying glaſs.

If the inſtrument be made a ſextant, in which caſe it will meaſure 120 degrees, it will be very convenient for meaſuring the diſtance of the ſun and moon for two or three days after the firſt, and before the laſt quarter, which cannot be done if it be made, as they uſually are, to meaſure only

90 degrees. And the obſervation of the diſtance of the ſun from the moon cannot be rendered too frequent, being more eaſily, and, in general, more exactly obſerved, than the diſtance of the moon from a ſtar in the night: beſides which, it is attended with another very great advantage, that the time of the day may be then directly aſcertained by an altitude of the ſun, taken by an aſſiſtant at the very inſtant of the meaſurement of the diſtance of the ſun from the moon, without depending upon the going of a watch for ſome hours, as will be generally neceſſary, where the diſtance of the moon from a ſtar is taken in the night.

The motion of the hand alone will not be exact and ſteady enough for moving the index in theſe nice obſervations of the meaſurement of the diſtance of the moon from the ſun or a ſtar. Therefore it will be neceſſary to perform this motion by means of a ſcrew; for, the quadrant being often to be held in a very inclined plane, it will be often impracticable, on account of the motion of the ſhip, to make the obſervation inſtantaneouſly; but, by means of the ſcrew, the index may be moved by gentle degrees, and each time after altering the ſcrew, the quadrant muſt be turned by the hand round the viſual ray, going to the ſtar as an axis, ſo as to make the moon's limb paſs by the ſtar, till at laſt, in paſſing by, it exactly coincides with it.

Beſides the two dark glaſſes commonly applied to theſe inſtruments, there muſt be added a third, much lighter than the others, in order to take off the exceſſive brightneſs of the moon, and the glare upon the horizon glaſs, which always attends it, except when the moon's creſcent is ſmall, or her light is accidentally weakened by a thin cloud.

The ſpeculums, as well as dark glaſſes, muſt be ground with their ſurfaces truly plane, and parallel to each other; for the doing of which, I underſtand, that ſome of the optical inſtrument makers are now maſters of, a particular and infallible method. The performance of many quadrants, otherwiſe very exact, is ſpoiled by an imperfection in this particular; and therefore too much care cannot be taken about it.

The contact of a ſtar with the moon's limb will be rendered much more diſcernible by the help of a ſmall teleſcope, magnifying two or three times. This muſt be contrived to have a motion parallel to itſelf, (like a parallel ruler) by which it may be brought nearer to, or carried farther from, the plane of the quadrant; and the moon, which is ſeen always by reflection, will appear more or leſs bright, according as more or leſs of her light is received by the teleſcope from the quickſilvered part of the object ſpeculum; or, by raiſing the teleſcope ſtill higher, ſhe will be ſeen entirely by reflection from the unſilvered part of the ſpeculum, which is generally the moſt convenient. The object glaſs of the teleſcope may be made to ſlide in its tube, in order to adjuſt it to the moſt perfect diſtinctneſs, for the eye of the obſerver.

Previous to all obſervations, but particularly that of the diſtance of the moon from the ſun, or ſtar, for finding the longitude, the obſerver ſhould adjuſt his quadrant with the greateſt care; a point of equal conſequence with the exact obſervation of the diſtance of the moon from the ſtar: This is ſo much the more neceſſary, as the adjuſtment is ſubject to alter ſenſibly, even from one day to another. The beſt object of all for this purpoſe is the horiſon of the ſea, when clear, and the examination is made beſt without the teleſcope;

teleſcope; only, if the obſerver is at all ſhort-ſighted, he ought to make uſe of a concave glaſs, properly ſuited to his eye, as he ought likewiſe to do in all other obſervations made without the teleſcope, as particularly in taking the altitudes of ſtars, or of the moon in the night. The obſerver ſhould be careful always to examine the adjuſtment of his quadrant in the day-time, when the horiſon is to be ſeen clearly, and particularly in the afternoon when he expects to make an obſervation the enſuing night. Should he have failed of making this examination the afternoon before an obſervation, he may examine what the error was, if any, the next morning, or he may make this examination by means of the moon itſelf, in which caſe it will be beſt to uſe the teleſcope. Inſtead of freſh adjuſting the quadrant before every obſervation, perhaps the following method of examining and allowing for the error of it, may be more advantageous. Turn the index of the quadrant till the horiſon of the ſea, or the moon, or any other proper object, appears as one, by the union of the reflected image with the object ſeen directly; then the number of minutes, by which o on the index differs from o on the arch, is the error of the adjuſtment. If o on the index ſtands advanced upon the quadrant before, or to the left hand of o on the arch, that number of minutes is to be ſubſtracted from all obſervations; but if it ſtands off the arch behind, or to the right hand of o on the arch, it muſt be added to the obſervations. By examining the error of adjuſtment in this Manner, by at leaſt three trials, and taking a medium of the reſults, one can ſcarce err above half a minute in determining the preciſe quantity of the error of the quadrant, whereas one may be miſtaken a minute or more in adjuſting the quadrant, which is but a ſingle operation. The obſerver would do well to write down in a book the error of adjuſtment thus found, and which way it is to be applied, whether it is additive, or ſubſtractive.

Beſides this adjuſtment, which is familiar to every one who uſes the inſtrument, there is another, which is too little known, and too little regarded, the neglect of which is often of great prejudice in common uſe, but would entirely defeat the end of theſe nice obſervations : I mean, the ſetting of the little ſpeculum to a paralleliſm with the great one, by the ſcrews on the foreſide of the quadrant. The manner of doing it is this : Hold the plane of the quadrant parallel to the horiſon, and the index being brought near to 0, if the horiſon of the ſea, ſeen by reflection in the little ſpeculum, is higher than the direct horiſon, ſeen by the ſide of it, unſcrew the neareſt ſcrew a little matter, and ſcrew up the oppoſite one, till the direct and reflected horiſons agree nearly. But if the reflected horiſon is lower than the true horiſon, unſcrew the ſcrew furtheſt from you, and ſcrew up the neareſt ſcrew, till the two horiſons agree nearly, taking care to leave the ſcrews both tight, by ſcrewing them up equally, if they are ſlack. If the reflected horiſon ſhould not differ more than five minutes from the true one, it will be of no ill conſequence. This adjuſtment, when once well made, will ſeldom want correction, provided the ſcrews are ſufficiently tight, and that they have not been touched. Nevertheleſs, for fear of any accidents, it will be proper to examine it, from time to time, in order to be aſſured that no material alteration has happened ; for a deviation of ſo ſmall a quantity as four or five minutes can be of no prejudice.

## CHAP. II.

### *Of the Obſervations neceſſary to be made for finding the Longitude at Sea, and the Manner of making them.*

THERE are four obſervations neceſſary to be made, according to the method here propoſed, in order to determine the longitude at ſea: The firſt is an altitude of the ſun, or ſome bright ſtar, for regulating a watch, by which the other obſervations are to be made, or, at leaſt, for determining exactly the error of its going. The next obſervation is, the diſtance of the moon's enlightened limb from the ſun, or a ſtar. The third and fourth obſervations are, the altitudes of the moon and the ſun, or the ſtar, from which the moon's diſtance is obſerved, to be taken by two obſervers aſſiſting the perſon who takes the diſtance of the moon from the ſun, or a ſtar, at the very inſtant, or, at the utmoſt, within a minute of the time he gives notice that he has compleated his obſervation. At the ſame inſtant, or at moſt within a quarter of a minute, and before the obſervers attempt to read off the degrees and minutes from their quadrants, ſomebody muſt note the hour, minute, and quarter part of a minute of the watch, regulated as mentioned before. Only, if the diſtance of the moon be taken from the ſun, the altitude of the ſun, taken at the ſame inſtant, will determine the time without the uſe of a watch; and therefore the firſt obſervation mentioned above will not be neceſſary. But if it be propoſed to obſerve the diſtance of the moon from a ſtar in the night, the altitude of the ſun will be neceſſary for regulating the watch, and ſhould be previouſly taken in the afternoon, not ſooner than two o'clock; but the nearer he is to being due weſt, the better; only care ſhould be taken, that their altitudes be not much under five degrees, on account of the uncertainty of refraction near the horiſon. Or, if an altitude of the ſun was not taken the afternoon before the obſervation of the diſtance of the moon from the ſtar, it might be taken the next morning after, for a good common watch would not vary above a minute in that interval of time, which produces an error only of a quarter of a degree of longitude.

Could the altitude of the bright ſtars be taken with certainty in the night, there would be no occaſion to depend upon the going of a watch at all. In fine ſummer nights, or when there is any ſmall appearance of twilight, thoſe obſervations may be made very well: and on ſuch occaſions, to make them uſeful for deriving the time, the ſtars muſt be ſo choſen, as not to be leſs than two hours from the meridian: the nearer they are to the prime vertical, or to being due eaſt or weſt, the more exact they will be for this purpoſe. But in general, the altitude of ſtars admit of too much uncertainty for the purpoſe of finding the time, though exact enough for the uſes intended to be derived from the third and fourth obſervations, in computing the effect of refraction and parallax. The altitude of the ſun's lower limb muſt be obſerved, as in the meridian obſervation, except the air ſhould be foggy, and the ſun's limbs ill defined, in which caſe it is better to take the altitude of his centre.

In order to take the diſtance of the moon from the ſun, the obſerver muſt look at the moon directly through the unfoiled part of the little ſpeculum, and having firſt let down one of the dark glaſſes uſed in taking the meridian altitudes, and having likewiſe brought the plane of the quadrant nearly into the arch of a great circle, going through the ſun and moon, he muſt ſhift the index gradually, and move or ſweep the arch of the quadrant alternately to the right hand and left, till he ſees the ſun and moon in view together, and has brought their neareſt limbs almoſt into contact. Let him then ſcrew down the plate to the arch, containing the ſcrew which is deſigned to give a more minute and regular motion to the index, and while he moves the index by the turning of the ſcrew, or immediately after, he muſt turn the quadrant round the viſual ray, going to the moon as an axis, ſo as to make the ſun ſeem to paſs by the moon's limb. Theſe operations are to be repeated till the neareſt limbs of the ſun and moon, in their apparent paſſage by each other, exactly touch one another outwardly at their neareſt approach, without cutting one into the other, which compleats the obſervation.

But, in order to take the diſtance of the moon from a ſtar, the obſerver muſt look at the ſtar directly, and holding the plane of the quadrant ſo as to paſs nearly through it and the moon, he muſt move the index (juſt as in the obſervation of the diſtance of the moon from the ſun) till the ſtar appears almoſt in contact with the moon's enlightened limb, whether it be the neareſt to, or furtheſt from, the ſtar. If the moon's enlightened limb be that furtheſt from the ſtar, the moon's reflected image muſt be brought beyond the ſtar. Only if a teleſcope be uſed of the ſort which ſhews objects upſide down, it muſt be carefully noted, that when the enlightened limb is really neareſt the ſtar, the moon will appear as if ſhe were brought beyond it; and when the enlightened limb is really furtheſt from the ſtar, the moon will appear as if ſhe were only brought to it. Before the full, the weſtern limb is the enlightened limb; and after the full, the eaſtern one; though this may be judged of certainly by the eye, within a day of the full on each ſide.

The lighteſt dark glaſs will generally be requiſite in theſe obſervations; and the ſcrew being applied for moving the index, muſt be turned gradually, and the quadrant at the ſame time, or immediately after, turned round the viſual ray, going to the ſtar as an axis, ſo as to make the moon's limb ſeem to paſs by the ſtar; which operation muſt be repeated till the middle of the ſtar (for it will ſometimes appear of a ſenſible breadth) ſhall, at the moon's neareſt approach, appear to paſs exactly upon her limb, without entering further within it. The obſervation being thus compleated, whether of the diſtance of the ſun and moon's limbs, or of a ſtar from the moon's limb, the obſerver has nothing to do but to read the degrees, minutes, and fraction of a minute, which he muſt eſtimate by his eye, off the quadrant; unleſs, which will be more convenient, he aſſiſts his ſight with a ſmall magnifying glaſs, of one and a half or two inches focus.

The following cautions to be uſed in reading off the obſervations may not be ſuperfluous. To hold the quadrant with the arch towards you, and the center directly from you, and to place your eye fully oppoſite, and nearly perpendicular to that part of the arch where the nonius appears to coincide with the diviſions; holding alſo the magnifying glaſs, if you uſe one, ſtraight before you, and parallel to the line of the diviſions, and taking care to have a full and true light, equally illuminating the part you look at, both to the right hand and to the left.

It may be proper to take notice, that it will be neceſſary to invert the quadrant, that is to ſay, to hold it with its face and centre downwards, when the object, whether it be the moon or the ſtar, which is to be ſeen directly, is to the right hand of the other object in the heavens, which is to be ſeen by reflection. This will be made familiar by a little experience.

It has been obſerved above, that the two other obſervations, namely, the altitudes of the moon and ſun, or ſtar, muſt be taken by two other obſervers, at the ſame inſtant, or at leaſt within a minute of the taking of the diſtance of the moon from the ſun, or ſtar. The altitude of the moon's upper or lower limb muſt be taken according to the illumination of her diſk. A little practice will make it eaſy to take the altitude of the upper limb, which is difficult at firſt, as the moon's upper limb, at her loweſt deſcent, muſt be made to ſweep the horiſon above her. But in dark nights it is better not to attempt to give the ſweep at all, but to hold the quadrant as nearly perpendicular to the horiſon as you can judge by your eye. Further, theſe obſervations of altitudes in the night will be made better, as the horiſon will be ſeen much clearer, by removing the little hole uſed in moſt quadrants to limit the ſight, or by looking by the ſide of it, which will produce no error that will be here of any prejudice.

It may be expected that I ſhould ſay ſomething with reſpect to the degree of exactneſs that may be attained in theſe ſeveral obſervations; I ſhall therefore freely deliver my opinion in this reſpect, which I think myſelf ſufficiently warranted in doing, from the repeated obſervations I have taken on board of ſhip, as well as on ſhore, without ever finding myſelf deceived. "That the altitudes of the ſun "may be taken with good quadrants to one, or, at the moſt, "two minutes, if the horiſon be tolerably clear; therefore, "the time may generally be found by the ſun, within a "quarter, or at moſt, half a minute, even in theſe great "northern latitudes, which is a degree of exactneſs ſuffi-

“ cient for the purpoſe. That the diſtance of the moon
“ from the ſun, or a ſtar, may be taken with good qua-
“ drants, well rectified, to about a minute, when the ſea is
“ not very rough; but even in rougher weather, if it does
“ not approach to a ſtorm, I apprehend, a careful obſerver
“ cannot well be miſtaken above two minutes in the ob-
“ ſervation, which produces an error only of about a de-
“ gree in the determination of the longitude; and even
“ then, by taking a medium of ſeveral obſervations, he may
“ arrive at a ſtill greater exactneſs. The altitudes of the
“ moon and a ſtar, taken in the night, I own, admit of
“ much greater degrees of error; but then, fortunately, it
“ is not required to have theſe altitudes with the ſame ex-
“ actneſs as is neceſſary in the other obſervations; ſince an
“ error of a whole degree in them will ſeldom be of more
“ prejudice, than an error of a ſingle minute in meaſuring
“ the diſtance of the moon from a ſtar; therefore, ten or
“ twenty minutes can be of no great prejudice; and a caſe
“ ſcarce ever occurred in ſo many obſervations, where the
“ altitudes could not be taken within theſe limits. But
“ ſhould a caſe occur in practice, as it rarely will, that they
“ cannot be properly obſerved, a rule is given at the end
“ for computing them.”

It has been here ſuppoſed, that the obſerver is acquainted with ſome of the principal ſtars by ſight, and alſo, that he knows which of them he ought to chuſe, in order to meaſure the diſtance of the moon from; for every ſtar is not proper for this purpoſe.

The following directions will inſtruct him in theſe particulars. The table in page 4, contains a catalogue of twelve ſtars of the firſt and ſecond magnitude, which are all that he will ever have need of, and therefore all that

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he ought ever to uſe for this purpoſe, being choſen neareſt to the zodiac. Out of theſe he muſt ſelect one in this manner, either to the eaſt or weſt of the moon, according as circumſtances will admit.

Let him find the moon's longitude and latitude from any common almanack, or ephemeris, at the time he intends to make his obſervations; or, if he is deſtitute of an ephemeris, he muſt compute the moon's place to the given time, reduced to the meridian of Greenwich, which is that of the tables, by adding at the rate of an hour for every fifteen degrees he is to the weſt, or ſubſtracting, if to the eaſt of it, (which muſt alſo be done, if he makes uſe of an ephemeris). In making this computation, he may neglect the equation of time, the ten ſmall equations, the equation of Anomaly, and the node, and the reduction to the ecliptic; and only take in the equations of the centre, evection, and variation: he may alſo neglect the correction of the latitude, called latitude 2d. Having obtained the moon's longitude and latitude nearly, if he wants a ſtar to the eaſt of the moon, he muſt look in Table, p. 4. for one having a greater longitude than the moon; or if he wants a ſtar to the weſt of the moon, he muſt look for one having a leſs longitude than the moon, and muſt ſo ſelect it, that its longitude may differ at leaſt ten degrees from that of the moon; how much more, does not ſignify; and that the difference of their latitudes, if they are both north, or both ſouth, or the ſum of their latitudes, if one is north, and the other ſouth, may not exceed the limits of the table in page 4. Should he not be able to find a ſtar within the limits of the table, which will hardly ever be the caſe, let him chuſe one which approaches neareſt to them. I ſhould adviſe always the uſing one of theſe ſeven ſtars of the catalogue, Aldebaran, Pollux, Regulus, the Virgin's Spike, Antares, Fomalhaut, or Markab, in preference to any of the remaining five ſtars, unleſs the former ſhould very much exceed the limits of the table in page 4. as, being brighter, they will be eaſier found, and alſo their contact with the moon's limb better diſcerned than that of dimmer ſtars.

An eaſy method now offers itſelf for the obſerver to find the ſtar in the heavens, ſhould he be unacquainted with it by ſight. He has nothing to do but to ſet the index of his quadrant to the number of degrees expreſſing the difference of the longitudes of the moon and ſtar, and direct his ſight either to the eaſt or weſt of the moon, according as the longitude of the ſtar is greater or leſs than that of the moon; and having found the moon upon the little ſpeculum, let him give a ſweep with the quadrant to the right and left, and he will find the ſtar he ſeeks for nearly in a line perpendicular to the line of the moon's horns, or longer axis, or, which is the ſame thing, in the line of the moon's ſhorter axis produced.

In order to attain the greater degree of exactneſs, it will be better to repeat the obſervations, till at leaſt three diſtances of the moon from the ſtar, and their correſponding altitudes, are obtained; but the more that are taken the better. The ſum of all the obſervations of the diſtances, divided by the number of them, is to be regarded as the diſtance at the middle time, which is in like manner obtained by adding together all the times ſhewn by the watch, and dividing their ſum by the number, as before. In like manner, the mean of the correſpondent altitudes muſt be found. But the interval of time between the extreme obſervations muſt not exceed half an hour; if it does, each obſervation muſt be cleared of refraction and parallax ſeparately, and the medium of the diſtances muſt be taken, after they are thus corrected. Or the obſervations, if numerous, may be divided into ſeveral ſets, each included within the limits of half an hour, and the medium of each being taken, and cleared of refraction and parallax, their medium may be taken as the true and correct diſtance at the mean of all the times.

I ſhall now recite a ſet of actual obſervations, taken by myſelf, and the officers of the ſhip, upon our coming into the Britiſh channel, on our return from St. Helena, in the night preceding the morning on which we made the Scilly iſlands; by computations from which, I ſhall exemplify each precept as I go along, and laſtly deduce the true longitude of the ſhip at the time. But I muſt here give a general caution once for all, and deſire the obſerver to take particular notice, that the time made uſe of in the following computations is according to aſtronomical reckoning, which begins the day from the preceding noon. The denomination of the day at noon is the ſame in the nautical, in the civil, and in the aſtronomical account; but as it is the cuſtom of mariners to entitle the day's works in their journals by the noon at which the day's work ends, theſe computations are to be made according to the day of the month with which the day's work begins; or, in other words, the computations falling in with the time of any day's work in the log-book, muſt be made from the day of the month, which is leſs by one than the title of the journal. Thus, in the following example, the obſervations fall in with the time of the day's work in the log-book, which is entitled May 10; but in the computations muſt be reckoned to belong to May 9, and to ſuch hour, minute, and ſecond, as they follow the noon of May 9; ſo that if they happen after midnight, they are not to be reckoned 1, 2, 3, &c. in the morning, but 13, 14, 15, &c. hours, counting the hours up to 24 hours, or the next following noon. In the example, the altitude of the ſun taken in the afternoon is to be entitled May 9, 1762, 5h. 55m. 26ſ. P. M. by the watch. The mean of the three diſtances of the moon from the Virgin's Spike, May 9, 11h. 33m. 42ſ. P. M. by the watch. The altitude of the ſun the following morning, May 9, 20h. 31m. 30ſ. P. M. by the watch.

*Obſervations made May 9, 1762, on Board of the Warwick Eaſt-Indiaman, upon coming into the Channel, on our Return from St. Helena to England, a few Hours before we made the Scilly Iſlands.*

May 9, 1762, time per watch, 5h. 55m. 26ſ. P. M. Apparent altitude of the ſun's lower limb from the horiſon of the ſea was taken 8 deg. 35½m. There is 3½m. to be added for the error of the adjuſtment of the quadrant. The height of the eye above the ſurface of the ſea was about 25 feet. Our latitude at this time, by allowing for the ſhip's run ſince noon, was 49d. 2m. N. and our longitude, by account, 7d. 11m. Weſt of the Royal Obſervatory at Greenwich.

Intending to take the diſtance of the moon from ſome ſtar about midnight, I turn 7d. 11m. our longitude reckoned from Greenwich, into time, by the table in page 3, which produces 28m. 44ſ. which I add to 12 hours, becauſe we were in weſt longitude, gives 12h. 28m. 44ſ. or 12½h. P. M. nearly by the meridian of Greenwich, to which time I ought to find the moon's longitude and latitude by any ephemeris, calculated for this meridian, or that of London. But ſuppoſing I had no ephemeris at hand, I muſt then make a rough calculation, according to the directions given in page 12, as follows.

Mean

| | Mean Long. of ⊙ | | | Long. ⊙'s Apog. | | | |
|---|---|---|---|---|---|---|---|
| | S. | ° | ′ | S. | ° | ′ | |
| 1762. | 9 | 10 | 6 | 3 | 8 | 49 | |
| May. | 3 | 28 | 17 | | | | |
| D. 9. | 0 | 8 | 52 | | | | |
| H. 12. | 0 | 0 | 30 | | | | |
| M. 30. | 0 | 0 | 1 | | | | |
| | 1 | 17 | 46 | —3 | 8 | 49 | |
| Equa. of ⊙'s centre | + | 1 | 28 | 1 | 17 | 46 | |
| Long of ⊙ | 1 | 19 | 14 | 10 | 8 | 57 | Mean An. ⊙ |

| | Mean Long. ☽ | | | Mean An. ☽ | | | Long. ☊ | | |
|---|---|---|---|---|---|---|---|---|---|
| | S. | ° | ′ | S. | ° | ′ | S. | ° | ′ |
| 1762. | 11 | 10 | 31 | 1 | 11 | 17 | 1 | 18 | 13 |
| May. | 4 | 21 | 10 | 4 | 7 | 48 | 0 | 6 | 21 |
| D. 9. | 3 | 28 | 35 | 3 | 27 | 35 | 0 | 0 | 28 |
| H 12. | 0 | 6 | 35 | 0 | 6 | 32 | 0 | 0 | 1 |
| M. 30. | 0 | 0 | 16 | 0 | 0 | 16 | — | 6 | 50 |
| | 8 | 7 | 7 | 9 | 23 | 28 | 1 | 11 | 23 |
| Eq. of centre | + | 5 | 37 | Arg. XI. of centre. | | | | | |
| | | | | | | | S. | ° | ′ |
| | 8 | 12 | 44 | Arg. XII. of evection | | | 3 | 12 | 18 |
| Evection | — | 1 | 19 | Arg. XIII. of variation | | | 6 | 22 | 11 |
| | 8 | 11 | 25 | | | | | | |
| Variation | | + | 28 | | | | | | |
| ☽'s Long. | 8 | 11 | 53 | | | | | | |
| ☽'s ☊ | 1 | 11 | 23 | | | | | | |
| Arg. of Lat. | 7 | 0 | 30 | | | | | | |
| ☽'s Lat. | | 2 | 37 S. | | | | | | |

With the ſun's longitude, 1 S. 19d. 14m. I take the equation of time out of the table, p. 9, — 3 m. 54 ſ. which ought to be ſubſtracted from 12 h. 30 m. but being ſo ſmall, I neglect it in this rough calculation.

The moon's long. being thus found to be 8 S. 11 d. 53 m. and her latitude 2 d. 37 m. S. I find, by the help of the tables in page 4, that the Virgin's Spike is a proper ſtar to compare the moon with, their difference of longitude being 51 d. 22 m. and their difference of latitude being only 5 m. the Virgin's Spike having leſs longitude, and conſequently being to the weſt of the moon. But as the full moon is paſt, the eaſtern limb is the enlightened one, which being moſt remote from the Virgin's Spike, 16 m. muſt be added to 51 d. 22 m. for the moon's ſemidiameter, which gives 51 d. 38 m. for the diſtance which the moon's limb will have from the Virgin's Spike, which is exact enough to ſet the index of the quadrant to for obſervation, and thence to find the ſtar, if it was not known.

## *Sequel of the Obſervations.*

1762, May 9. Time by the watch, 11 h. 26 m. 45 ſ. P. M. Diſtance of the moon's eaſtern and remoteſt limb from the Virgin's Spike was meaſured 51 d. 38 m. by the Hadley's quadrant; but 3⅓ m. is to be added for the error of adjuſtment. At the ſame time, the apparent altitude of the moon's lower limb from the horiſon of the ſea was obſerved 11 d. 56 m. and the apparent altitude of the ſtar 25 d. 40 m, both including the dip, about 4 m. but free from any error of the adjuſtment of the quadrant.

In like manner, at 11 h. 32 m. 35 ſ. and 11 h. 41 m. 45 ſ. P. M. by the watch, the apparent diſtances of the moon's limb from the Virgin's Spike, by the quadrant, were 51 d. 40 m. and 51 d. 44 m. the apparent altitudes of the moon's lower limb from the horiſon of the ſea, 12d. 18m. and 12d. 39m. and thoſe of the ſtar 25d 0m. and 23d. 57m.

Though the altitude of the ſun taken in the afternoon might be ſufficient for correcting the watch, yet for regulating it with greater certainty, another altitude of the ſun's lower limb was taken the next morning at 8h. 31m. 30ſ. or rather adding 12 hours, at 20d. 31m. 30ſ. P. M. and was found 42d. 22½m. There is 2½m. to be added for the error of the quadrant. The height of the eye above the ſea was about 17 feet. Our latitude at that time was 49d. 30m. N. and we had made 39m. of longitude to the eaſt, ſince the altitude of the ſun taken in the afternoon.

# C H A P. III.

## *To compute the apparent or ſolar Time from the obſerved Altitude of the Sun, or a known Star, and thence to find the apparent Time of the Obſervation of the Diſtance of the Moon from the Sun or Star.*

THE firſt thing to be done in computing the longitude from the obſervations given, is to find the hour of the obſervation of the diſtance of the moon from the ſun or ſtar. In order to this, we muſt find the error of the watch, that is to ſay, how much it is too faſt or too ſlow, by the altitude of the ſun or bright ſtar taken for this purpoſe. From the obſerved altitude of the ſun's lower limb, ſubſtract the ſum of the dip and refraction, taken out of the tables in page 1, and to the remainder add 16 minutes for the ſun's ſemidiameter, and you have the true altitude of the ſun's centre. Or, if the ſun's upper limb was obſerved, ſubſtract the ſum of the dip, refraction, and 16 min. for the ſun's ſemidiameter; but if the altitude of his centre was taken, ſubſtract the ſum of the dip and refraction. Subſtract the true altitude of the ſun thus found from 90 deg. and you have his true zenith diſtance.

In like manner the obſerved altitude of a ſtar muſt be leſſened by the ſum of the dip and refraction, and the complement to 90 is the true zenith diſtance. Take the declination of the ſun out of the tables, which are to be found in all books of navigation, which declination being computed for the noon of ſome fixed meridian, ſuppoſe London, muſt be corrected by allowing both for your longitude from thence, and the diſtance of the time from noon eſtimated nearly. The beſt way is to add your longitude from London or Greenwich, turned into time, to the hour of the day, if you are to the weſt of it; or ſubſtract it, if you are to the eaſt of it, which gives the true hour at Greenwich; and ſay, as 24 hours is to this number of hours, ſo is the ſun's daily variation of declination from noon to noon, to a number of minutes, which add to the ſun's declination in the table at noon, if it is increaſing, or ſubſtract if it is decreaſing, and you will obtain the ſun's true declination required.

The ſtar's declinations are found in the table, page 2 and 3. The ſun or ſtar's declination, if of the ſame denomination with the latitude of the place, ſubſtract from 90 deg. but if of a different denomination, add to 90 deg. and you have the diſtance of the ſtar from the pole of the world, which is above the horiſon. Find alſo the latitude of the ſhip at the taking the altitude of the ſun or ſtar, by allowing for the ſhip's run from the latitude determined by the laſt meridian obſervation, and take its complement to 90, or the colatitude. Now add together the zenith diſtance, polar diſtance, and colatitude, and take half the ſum; then add together the arithmetical complement of the ſine of the colatitude, the arithmetical complement of the ſine of the polar diſtance, the ſine of the half-ſum found above, leſſened by the colatitude, and the ſine of the ſaid half-ſum, leſſened by the polar diſtance; half the ſum of theſe four logarithms is the ſine of an arc, which doubled gives the true diſtance of the ſun or ſtar from the meridian. Five places of logarithms will be ſufficient in this computation. The diſtance of the ſun from the meridian turned into time, at the rate of an hour for every 15 degrees, and 1 minute of time for every 15 minutes, and 1 ſecond of time for 15 ſeconds, which is expeditiouſly done by the table in p. 3 and 4. gives the apparent time of the day, if it be the afternoon; or, ſubſtracted from 12 hours, gives the apparent time of the day, if it be forenoon.

To find the apparent time from the altitude of a ſtar, ſubſtract its diſtance from the meridian from its right aſcenſion (taken out of table page 2 and 3) if it be to the eaſt of the meridian, or add it to the right aſcenſion, if it be to the weſt of the meridian; the difference or ſum is the right aſcenſion of the mid-heaven. To the time of the day eſtimated nearly, add your longitude from Greenwich, turned into time, if you are to the weſt of Greenwich; or ſubſtract the longitude turned into time, if you are to the eaſt of Greenwich, gives the time reduced to the meridian of Greenwich; to which compute the ſun's longitude, according to the directions in the beginning of the next chapter, and hence find his right aſcenſion by the table, page 27 and 28, making a proportion for the minutes of the ſun's longitude above the next inferior degree. Now ſubſtract the ſun's right aſcenſion from the right aſcenſion of the mid-heaven, borrowing 360 degrees, if neceſſary; the remainder turned into time, by table in page 3 and 4, is the apparent time, reckoned from the preceding noon.

The difference between the apparent time thus found, whether by the altitude of the ſun or a ſtar, and the time ſhewn by the watch, at the inſtant of taking the ſaid altitude, ſhews how much the watch is too faſt or too ſlow for apparent time, which difference being applied as a correction to the time ſhewn by the watch, when the diſtance of the moon from the ſtar was taken, being added thereto if the watch is too ſlow, or ſubſtracted therefrom if it is too faſt, gives the apparent time of the obſervation.

*Example of a Computation of the apparent Time from the Altitude of the Sun, recited above, taken May* 9, 1762, 5h. 55m. 26ſ. P. M. *per Watch*

| | ° | ′ |
|---|---|---|
| Altitude of the ſun's lower limb by the quadrant | 8 | 35½ |
| Add. on account of the error of the quadrant | + | 3½ |
| Altitude of the ſun's lower limb corrected | 8 | 39 |
| Subſtract ſum of dip 5′, and refraction 6′ | — | 11 |
| True altitude of the ſun's lower limb | 8 | 28 |
| Add ſemidiameter of the ſun | + | 16 |
| | 8 | 44 |
| Subſtract from | 90 | 0 |
| True zenith diſtance of the ſun | 81 | 16 |
| Diſtance of the ſun from the elevated or north pole, =90°—17° 28′ his declination at that time | =72 | 32 |
| Complement of the latitude =90---49° 21′ | =40 | 39 |
| Sum of zen. diſt. of ſun. pol. diſt. of ſun, and colat. | 194 | 27 |
| Half the ſum | 97 | 13½ |

| | | |
|---|---|---|
| Ar. compl. ſin. colat. | 40.39 | 0.18613 |
| Ar. compl. ſin. pol. diſt. | 72.32 | 0.02050 |
| Sin. of ½ ſum — colat.=97° 13½′—40° 39′ | =56.34 | 9.92148 |
| Sin. of ½ ſum—pol. diſt.=97 13½—72 32 | =24.41½ | 9.62090 |
| Sum of four logarithms | | 19.74901 |
| Half ſum | | 9.87450 |

Is ſine of 48° 30½′
2

Sun's horary angle 97 1

This, by table, page 3 and 4, gives the apparent time, 6 h. 28 m. 4 ſ. P. M. The time by the watch was 5 h. 55 m. 26 ſ. P. M. Hence the watch is 32 m. 38 ſ. too ſlow for apparent time.

I ſhall now give an example of the computation of the time from the altitude of the Virgin's Spike, recited above, taken May 9, 1762, at 11 h. 26 m. 45 ſ. P. M. per watch, at the time of taking the firſt diſtance of the moon from the Virgin's Spike. But this is to be looked upon only as an example of the method of calculation, the time determined from hence not being to be depended on ſo exactly as that from the altitudes of the ſun, for want of a better horiſon. The latitude of the ſhip at that time was 49 d. 23 m. N. and ſhe had made 17½ m. of longitude to the eaſt, ſince the altitude of the ſun in the afternoon. The right aſcenſion of Spica Virginis is at this time 198 d. 10 m. 37 ſ. and its declination 9 d. 54 m. 45 ſ. S.

| | ° | ′ |
|---|---|---|
| Obſerved altitude of Spica | 25 | 40 |
| Subſtract ſum of dip 4′, and refraction 2′ | --- | 6 |
| True altitude of Spica ——— | 25 | 34 |
| | 90 | |
| Subſtract from 90 leaves true ——— | 64 | 26 |
| Zenith diſtance of Spica Virginis, diſtance of Spica from elevated or north pole = 90 + 9° 55′ = ——— | 99 | 55 |
| Colatitude = 90---49° 23′ = | 40 | 37 |
| Sum of zenith diſtance of the ſtar, polar diſtance of the ſtar, and the colatitude ——— | 204 | 58 |
| Half ſum ——— ——— | 102 | 29 |

Ar,

| | | | |
|---|---|---|---|
| Ar. compl. ſin. colatitude | —— | 40.37 | 0.18642 |
| Ar. compl. ſin. pol. diſt. | —— | 99.55 | 0.00654 |
| Sin. half ſum --- colat. | =102.29---40.37= | 61.52 | 9.94540 |
| Sin. half ſum --- pol. diſt. | =102.29---99.55= | 2.34 | 8.65110 |
| Sum of four logarithms | —— | | 18.78946 |
| Half ſum | —— —— | | 9.39473 |
| is ſine of | —— —— | 14° $22\frac{1}{8}'$ | |
| | | 2 | |
| Doubled, is horary angle, | | 28 $44\frac{1}{4}$ | |
| or diſtance of Spica Virginis from the meridian to the weſt; therefore, add it to the right aſcenſion of Spica Virginis | | 198 $10\frac{1}{2}$ | |
| Gives right aſcenſion of mid heaven | | 226 55 | |

To the eſtimated time, which is exactly midnight, or 12h. P. M. add 28m. for about 7d. of longitude weſt of Greenwich, gives the time reduced to the meridian of Greenwich, 12h. 28m. or $12\frac{1}{2}$h. P. M. to which time compute the ſun's longitude, which comes out 1S. 19d. 15m. Hence the ſun's right aſcenſion, by table, page 27 and 28, is 46d. 47m, which ſubſtract from 226d. 55m. the right aſcenſion of the mid-heaven, found above, leaves 180d. 8m. for the apparent time in parts of the equator, which, by table, page 3 and 4, gives the apparent time 12h. 0m. 32ſ. But the time ſhewn by the watch was 11h. 26m. 45ſ. hence the watch is 33m. 47ſ. too ſlow for apparent time. By the altitude of the ſun taken in the afternoon, the watch was then 32m. 38ſ. too ſlow for apparent time; but ſince that time, the ſhip having made $17\frac{1}{2}$m. of a degree of longitude towards the eaſt = 1m. 10ſ. of time; the watch ought to be ſo much ſlower than it was in the afternoon, or 33m. 48ſ. too ſlow for apparent time, with which the obſervation of the Virgin's Spike happens to agree exactly.

*Computation of the Time from the Altitude of the Sun recited above, taken May* 9, 20h. 31m. 30ſ. P.M. *by the Watch.*

| | ° | ′ | |
|---|---|---|---|
| Obſerved altitude of the ſun's lower limb | 42 | 22½ | |
| Add error of quadrant —— | + | 2½ | |
| Altitude corrected for error of quadrant | 42 | 25 | |
| Subſtract ſum of dip 4′, and refraction 1′ | — | 5 | |
| True altitude of the ſun's lower limb | 42 | 20 | |
| Add for ſemidiameter of the ſun | + | 16 | |
| True altitude of the ſun's centre | 42 | 36 | |
| Subſtract from —— | 90 | 0 | |
| True zenith diſtance of the ſun | 47 | 24 | |
| Colatitude = 90° — 49° 30′ = | 40 | 30 | |
| Diſtance of the ſun from elevated or north pole 90° — 17° 39′ = | 72 | 21 | |
| Sum —— —— | 160 | 15 | |
| Half ſum —— —— | 80 | 7½ | |
| Ar. compl. ſin. colat. —— | 40.30 | | 0.18746 |
| Ar. compl. ſin. pol. diſt. —— | 72.21 | | 0.02094 |
| Sin. half ſum — colat. = 80.7½ — 40.30 = | 39.37½ | | 9.80465 |
| Sin. half ſum — pol. diſt. = 80.7½ — 72.21 = | 7.46½ | | 9,13124 |
| Sum —— —— | | | 19.14429 |
| Half ſum —— —— | | | 9.57214 |

is ſine of 21° 55½′

2

Doubled, is 43 51 = horary angle, or diſtance of the ſun from the meridian to the eaſt; and turned into time by table in page 3 and 4, = 2h. 55m. 24ſ. which, ſubſtracted from 12, leaves 9h. 4m. 36ſ. A. M. apparent time, or rather 21h. 4m. 36ſ. P. M. reckoned from the preceding noon. The watch was 8h. 31m. 30ſ. hence the watch is 33m. 6ſ. too ſlow for apparent time.

By the altitude of the ſun in the afternoon before, the watch was 32m. 38ſ. too ſlow for apparent time; therefore it ſeems to have loſt 28ſ. ſince that time, in 14 hours and a half; but the ſhip has made 39m. of longitude to the eaſt, =2m. 36ſ. of time, in the interval; and conſequently the watch ought to have appeared to have loſt 2m 36ſ. of time; but it appears to have loſt only 28ſ. therefore the watch has really got the difference between 2m. 36ſ. and 28ſ. or 2m. 8ſ. in 14½ hours, which agrees very well with the reſult of all the obſervations made of late, by which, when the change of meridians is allowed for, it gets at the rate of about 3¼m. in a day upon ſolar time.

As the altitude of the Virgin's Spike was not taken to compute the time from, nor could be had ſufficiently exact to determine it certainly within a minute, through the obſcurity of the horiſon, I ſhall deduce the error of the watch from the altitudes of the ſun. By the firſt altitude of the ſun, at 5h. 55m. 26ſ. P. M. by watch, the watch appears to have been then 32m. 38ſ. too ſlow for apparent time, which might be added to the mean of the three times ſhewn by the watch at the taking of the three diſtances of the moon from the Virgin's Spike, to find the apparent time correct.

But as the watch appears, as well by the two altitudes of the ſun above recited, as by all the obſervations made of late, after allowing for the change of the meridians, to be gaining at the rate of about 3¼ m. per day upon ſolar time, I will ſuppoſe it to have got at the ſame rate between the taking of the altitude of the ſun in the afternoon, and the time of the taking the diſtance of the moon from the ſtar. The three times by the watch, at the taking of the three diſtances of the moon's limb from the Virgin's Spike, were, 11h. 26m. 45ſ. 11h. 32m. 35ſ. 11h. 41m. 45ſ. the ſum of which, divided by 3, is 11h. 33m. 42ſ. the mean time of the three obſervations by the watch. The interval of time between 5h. 55m. 26ſ. the time between the taking of the ſun's altitude in the afternoon and this is about 5½h. in which time the watch will get 45ſ. at the rate of 3¼m. per day. But at 5h. 55m. 26ſ. P. M. by the watch, it was 32m. 38ſ. too ſlow for apparent time; and at 11h. 33m. 42ſ. having got 45ſ. it will be then only 31m. 53ſ. too ſlow for apparent time, which, added to 11h. 33m. 42ſ. gives the apparent time of the obſervations of the diſtance of the moon's limb from the Virgin's Spike, May 9, 12h. 5m. 35ſ. P.M.

# C H A P. IV.

## *To compute the Sun's Longitude, the Moon's Longitude, Latitude, horiſontal Parallax, Semidiameter, and hourly Motion, at any given Time, by the Meridian of Greenwich.*

TO the apparent time of the obſervations of the diſtance of the moon from the Virgin's Spike, which has been found above to be, May 9, 12h. 5m. 35ſ. P. M. add 28m. 44ſ. of time, which, by table, page 3 and 4, anſwers to 7d. 11m. of longitude weſt from Greenwich, by account when the altitude of the ſun was taken in the afternoon, by which the watch was corrected. The ſum is 12h. 34m. 19ſ. the apparent time at Greenwich, according to the ſhip's reckoning. To this time the ſun and moon's longitude, latitude, &c. muſt be computed. If the ſhip had been eaſt of Greenwich, the longitude by account turned into time, muſt have been ſubſtracted from the apparent time. It may be thought, the apparent time of the obſervation of the diſtance of the moon from the ſtar ought to be reduced to the time at Greenwich, by the longitude of the ſhip by account at that time; but as the watch, corrected by the altitude of the ſun, muſt continue to ſhew the time according to the meridian where that obſervation was made, the longitude of the ſhip's account at that time muſt be uſed.

### 1. *To find the Sun's Longitude.*

To the ſun's mean longitude for the beginning of the year, add his mean motions to the beginning of the month; and likewiſe for the day of the month, hour, minute, and ſecond of time given, according to the tables in page 6, the ſum is the mean longitude of the ſun at the given time. Only in leap year, in the months of January and February, compute for the day of the month preceding the given day. In like manner, to the longitude of the ſun's apogee for the beginning of the year, add his motion to the beginning of the month, and for days. The ſum ſubſtracted from the ſun's mean longitude, found above, is his mean anomaly, with which take out the equation of the centre from page 7 and 8; this added to, or ſubſtracted from, his mean longitude, gives his true longitude nearly. With this take out the equation of time from the table in page 9, and find by the table in page 6, the motion of the ſun anſwering to that number of minutes and ſeconds of time, and add it to, or ſubſtract it from, the ſun's longitude found nearly above, according to the ſign of the equation of time, gives the true longitude of the ſun.

In the example following, the mean longitude of the ſun is 1 S. 17d. 46m. 22ſ. and the longitude of his apogee 3 S. 8d. 49m. 57ſ. which being ſubſtracted from the former, leaves 10 S. 8d. 56m. 25ſ. the mean anomaly of the ſun, with which take the equation of the ſun's centre out of table, page 8, +1d. 28m. 38ſ. to be added to the mean longitude of the ſun, 1 S. 17d. 46m. 22ſ. whence the true longitude of the ſun nearly is 1 S. 19d. 5m. 0ſ. With this take the equation of time from table, page 9, —3m. 54ſ. to which the motion of the ſun correſponding by table, page 6, is —7 ſ. to be ſubſtracted from the true longitude of the ſun found nearly, (becauſe the equation of time is ſubſtractive) leaves 1 S. 19d. 14m. 53ſ. the true longitude of the ſun.

### 2. *To compute the Moon's Longitude, Latitude, &c.*

To the apparent time at Greenwich, by which the ſun's longitude was computed, add or ſubſtract the equation of time, according to its ſign, and you have the mean time at Greenwich by account; to which time the moon's longitude, latitude, &c. muſt be computed by the tables.

N. B. In ſtrictneſs the equation of time ought to be made uſe of which belongs to the ſun's longitude, at the time when the altitude of the ſun or ſtar was taken, by which the watch was corrected; and not that at the time of the obſervation of the diſtance of the moon from the ſtar: but as the interval of theſe times need never exceed 12 hours, the error hence ariſing can never exceed a quarter of a minute of time, which is of no conſequence in this caſe.

In the example the apparent time at Greenwich by account is 12h. 34m. 19ſ. P. M. from which the equation of time, —3m. 54ſ. being ſubſtracted, leaves 12h. 30m. 25ſ. P. M. the mean time at Greenwich by account; to which time compute the moon's longitude, latitude, &c. in the following manner.

From the tables in page 10 and 11, take out the mean longitude of the moon, mean anomaly of the moon, and mean longitude of the aſcending node for the beginning of the year, and the mean motions to the beginning of the month, and for the days, hours, minutes, and ſeconds of the mean time laſt found. Add all the numbers belonging to the mean longitude together, and likewiſe all belonging to the mean anomaly together, and you have the mean longitude and mean anomaly of the moon at the given time.

But from the mean longitude of the node for the beginning of the year ſubſtract the ſum of all the mean motions belonging to the node, and you have the mean longitude of the aſcending node at the given time. Thus, in the example, the mean longitude of the moon comes out 8 S. 7d. 8m. 27ſ. the mean anomaly of the moon, 9 S. 23d. 28m. 24ſ. and the mean longitude of the aſcending node, 1 S. 11d. 21m. 12ſ.

Next find the arguments of the ten firſt equations in the following manner.

Equ. I. The argument of the firſt equation is the mean anomaly of the ſun, found above in computing the ſun's longitude. This in the example is 10 S. 8d. 56m. Therefore the firſt equation, by table 1, of the moon, is — 8m. 39ſ.

Equ. II. From the mean longitude of the moon, 8 S. 7d. 8m. ſubſtract the true longitude of the ſun, 1 S. 19d. 15m. gives the mean diſtance of the moon from the ſun, 6d. 17m. 53ſ. double this diſtance is 1 S. 5d. 46m. to which add the mean anomaly of the ſun, 10 S. 8d. 56m. gives the argument of the ſecond equation, 11 S. 14d. 42m. whence the ſecond equation is +14ſ.

Equ. III. From double the diſtance of the moon from the ſun, 1 S. 5d. 46ſ. ſubſtract the mean anomaly of the ſun, 10 S. 8d. 56m. gives the argument of the third equation, 2 S. 26d. 50m. whence the third equation is —1m. 2ſ.

Equ. IV. From argument the ſecond, 11 S. 14d. 42m. ſubſtract the mean anomaly of the moon, 9 S. 23d. 28m. gives the argument of the fourth equation, 1S. 21d. 14m. whence the fourth equation is +1m. 24ſ.

Equ. V. From argument the third, 2S. 26d. 50m. ſubſtract the mean anomaly of the moon, 9S. 23d. 28m. gives the argument of the fifth equation, 5S. 3d. 22m. whence the fifth equation is + 33ſ.

Equ. VI. To double the diſtance of the moon from the ſun, 1S. 5d. 46m. add the mean anomaly of the moon, 9S. 23d. 28m. gives the argument of the ſixth equation, 10S. 29d. 14m. whence the ſixth equation is —46ſ.

Equ. VII. From the mean longitude of the moon, 8S. 7d. 8m. ſubſtract the mean longitude of the node, 1S. 11d. 21m. gives the mean diſtance of the moon from the node, 6S. 25d. 47m. from the double of which diſtance, or 1S. 21d. 34m. ſubſtract the mean anomaly of the moon, 9S. 23d. 28m. gives the argument of the ſeventh equation, 3S. 28d. 6m. whence the ſeventh equation is +51ſ.

Equ. VIII. From the mean anomaly of the moon, 9S. 23d. 28ſ. ſubſtract the mean anomaly of the ſun, 10S. 8d. 56m. gives the argument of the eighth equation, 11S. 14d. 32m. whence the eighth equation is —11ſ.

Equ. IX. From the mean longitude of the node, 1S. 11d. 21m. ſubſtract the true longitude of the ſun, 1S. 19d. 15m. gives the diſtance of the node from the ſun, or the argument of the ninth equation, 11S. 22d. 6m. whence the ninth equation is —13ſ.

Equ. X. From the diſtance of the moon from the ſun, 6S. 17d. 53m. ſubſtract the mean anomaly of the moon, 9S. 23d. 28m. gives the argument of the tenth equation, 8S. 24d. 25m. whence the tenth equation is +10ſ.

Now add the ſum of ſuch of the ten equations as are additive +3m. 12ſ. to the mean longitude of the moon, 8S. 7d. 8m. 27ſ. gives 8S. 7d. 11m. 39ſ. and from thence ſubſtract the ſum of the other of the ten equations, which are ſubſtractive —10m. 51ſ. gives the longitude of the moon correct, 8S. 7d. 0m. 48ſ.

Equ. XI. and XII. Correct the mean anomaly of the moon, 9S. 23d. 28m. 24ſ. by adding the ſum of ſuch of the ten equations as are additive +3m. 12ſ. and ſubſtracting the ſum of the reſt, which are negative —10m. 51ſ. and further apply the double of the firſt equation, or —17m. 18ſ. gives the mean anomaly of the moon correct, or the argument of the eleventh equation of the centre, 9S. 23d. 3m. 27ſ.

From the longitude of the moon correct, 8S. 7d. 0m. 48ſ. ſubſtract the longitude of the ſun, 1S. 19d. 14m. 53ſ. gives the diſtance of the moon from the ſun correct, 6S. 17d. 45m. 55ſ. from which diſtance doubled, 1S. 5d. 31m. 50ſ. ſubſtract the mean anomaly of the moon correct, or argument the 11th, 9S. 23d. 3m. 27ſ. leaves the argument of the twelfth equation, the evection, 3S. 12d. 28m. 23ſ.

With the mean anomaly of the moon correct, 9S. 23d. 3m. 27ſ. take out the 11th equation of the centre, +5d. 38m. 39ſ. which, applied to the longitude of the moon correct, 8S. 7d. 0m. 48ſ. gives the longitude of the moon corrected by the equation of the centre, 8S. 12d. 39m. 27ſ.

With argument 12th, 3 S. 12d. 28m. 23ſ. take out the 12th equation, the evection, —1d. 19m. 3ſ. which applied to the longitude of the moon corrected for the equation of the centre, 8 S. 12d. 39m. 27ſ. gives the longitude of the moon equated, 8 S. 11d. 20m. 24ſ.

Equ. XIII. From the longitude of the moon equated, 8 S. 11d. 20m. 24ſ. ſubſtract the true longitude of the ſun, 1 S. 19d. 14m. 53ſ. gives the argument of the 13th equation, 6 S. 22d. 5m. 31ſ. whence the 13th equation, the variation is + 29m. 7ſ. which, applied to the longitude of the moon equated, 8 S. 11d. 20m. 24ſ. gives the longitude of the moon reckoned in her orb, 8 S. 11d. 49m. 31ſ.

Equ. XIV. To the mean longitude of the moon's aſcending node, 1 S. 11d. 21m. 12ſ. apply the firſt of the ten equations —8m. 39ſ, gives the longitude of the moon's aſcending node corrected, 1 S. 11d. 12m. 33ſ. which ſubſtract from the longitude of the moon in her orb, 8 S. 11d. 49m. 31ſ. and you have the argument of reduction and of latitude, 7 S. 0d. 36m. 58ſ. which gives equ. 14, the reduction —6m. 6ſ. which, applied to the longitude of the moon in her orb, 8 S. 11d. 49m. 31ſ. gives the true longitude of the moon in the ecliptic, 8 S. 11d. 43m. 25ſ.

Latitude I. With the argument of latitude, 7 S. 0d. 36m. 58ſ. take out latitude firſt, is 2d. 37m. 17ſ. South.

Latitude II. To argument the 9th, 11 S. 22d. 6m. add argument the 13th, 6 S. 22d. 5m. gives argument of latitude ſecond, 6 S. 14d. 11m. whence latitude ſecond is 2m. 9ſ. S. The ſum of this and latitude firſt, 2d. 37m. 17ſ. S. as they are both of the ſame kind, gives the moon's true latitude,

titude, 2d. 39m. 26ſ. S. If theſe two latitudes had been of contrary denominations, that is to ſay, one north and the other ſouth, their difference would have been the true latitude of the moon, of the ſame kind with the greater latitude.

With argument 11th of equation of centre, 9S. 23d. 3m. take out the equatorial parallax of the moon, 55m. 47ſ. With argument 12th of evection, 3S. 12d. 28m. take out the firſt equation of parallax, +8ſ. and with argument 13th of variation, 6S. 22d. 5m. take out the ſecond equation of parallax, +20ſ. which being both applied to the equatorial parallax, 55m. 47ſ. give the horiſontal parallax of the moon correct, 56m. 15ſ. From hence find the horiſontal ſemidiameter of the moon by table, page 23, 15m. 21ſ. to which add from the table in the ſame page, 3ſ. for the augmentation for the altitude of 12d. gives the apparent ſemidiameter of the moon, 15m. 24ſ.

From the table of the moon's hourly motion in page 24, with argument 11th of centre, take out the moon's hourly motion, 31m. 22ſ. With argument 12th of evection, take out the firſt correction of the hourly motion, +8ſ. With the mean diſtance of the moon from the ſun, uſed in making out the ſecond of the firſt ten equations, take out the ſecond correction of the hourly motion, +34ſ. Theſe both applied to 31m. 22ſ. give the true hourly motion of the moon, 32m. 4ſ.

### *An Example of the Calculation of the Sun's Longitude, May 9, 1762, at 12h. 34m. 19ſ. P. M. apparent Time, by the Meridian of the Royal Obſervatory at Greenwich.*

| Apparent Time. | Longitude of ⊙ | | | | Apog. of ⊙ | | | |
|---|---|---|---|---|---|---|---|---|
| | S. | ° | ′ | ″ | S. | ° | ′ | ″ |
| 1762. | 9 | 10 | 6 | 28 | 3 | 8 | 49 | 35 |
| May. | 3 | 28 | 16 | 40 | | | | 21 |
| D. 9. | | 8 | 52 | 15 | | | | 0 |
| H. 12. | | | 29 | 34 | | | | 0 |
| M. 34. | | | 1 | 24 | | | | 0 |
| S. 19. | | | | 1 | | | | 0 |
| | 1 | 17 | 46 | 22 | 3 | 8 | 49 | 55 |
| Equ. ⊙'s centre | + | 1 | 28 | 38 | 1 | 17 | 46 | 22 |
| Long. ⊙ nearly | 1 | 19 | 15 | 0 | 10 | 8 | 56 | 27 |
| Equ. of time | | | — 3 | 54 | Mean anomaly of ⊙ | | | |
| Corr. mot. of ⊙ | | | — | 7 | Arg. of equ. of ⊙'s centre. | | | |
| True long. of ⊙ | 1 | 19 | 14 | 53 | | | | |

| | | | | |
|---|---|---|---|---|
| Apparent time | 12 | 34 | 19 | P. M. |
| Equation of time | — | 3 | 54 | |
| Mean time | 12 | 30 | 25 | P. M. |

## *An Example of the Calculation of the Moon's Longitude, Latitude, Horiſontal Parallax, Semidiameter, and hourly Motion, May 9, 1762, at 12 h. 30 m 25 ſ. P. M. mean Time by the Meridian of the Royal Obſervatory at Greenwich.*

| Mean Time. | Mean long. ☽ S. | ° | ′ | ″ | Mean Anom. ☽ S. | ° | ′ | ″ | Mean Long. ☊ S. | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1762. | 11 | 10 | 31 | 9 | 1 | 11 | 16 | 53 | 1 | 18 | 12 | 43 |
| May. | 4 | 21 | 10 | 3 | 4 | 7 | 47 | 54 | | 6 | 21 | 16 |
| D. 9. | 3 | 28 | 35 | 15 | 3 | 27 | 35 | 6 | | 0 | 28 | 36 |
| H. 12. | | 6 | 35 | 18 | | 6 | 31 | 57 | | | 1 | 35 |
| M. 30. | | | 16 | 28 | | | 16 | 20 | | | | 4 |
| S. 25. | | | | 14 | | | | 14 | — | 6 | 51 | 31 |
| | 8 | 7 | 8 | 27 | 9 | 23 | 28 | 24 | 1 | 11 | 21 | 12 |

| | S. | ° | ′ | ″ |
|---|---|---|---|---|
| Sum of ten equat. | | — | 7 | 39 |
| Long. ☽ corr. | 8 | 7 | 0 | 48 |
| Equat. XI. of cen. | + | 5 | 38 | 39 |
| | 8 | 12 | 39 | 27 |
| Equ. XII. evect. | — | 1 | 19 | 3 |
| Long. ☽ Eq. | 8 | 11 | 20 | 24 |
| Equ. XIII. variat. | | + | 29 | 7 |
| Long. ☽ in orb | 8 | 11 | 49 | 31 |
| Equ. 14 Reduct. | | — | 6 | 6 |
| Long. ☽ in eclipt. | 8 | 11 | 43 | 25 |

| | ° | ′ | ″ | |
|---|---|---|---|---|
| Lat. I. | 2° | 37′ | 17″ | S. |
| Lat. II. | | 2 | 9 | S. |
| True lat. ☽ | 2 | 39 | 26 | S. |

Horiſontal parallax of ☽

| | | ′ | ″ |
|---|---|---|---|
| Arg. XI. | | 55′ | 47″ |
| Arg. XII. | | + | 8 |
| Arg. XIII. | | + | 20 |
| Hor. par. of ☽ | | 56 | 15 |
| Hor. ſemidiam. ☽ | | 15 | 21 |
| Augm. for alt. | 12° | + | 3 |
| App. ſemidiam. ☽ | | 15 | 24 |

Hourly motion of ☽

| | ′ | ″ |
|---|---|---|
| Arg. XI. | 31′ | 22″ |
| Arg. XII. | + | 8 |
| Mean diſt. ☽ a ☉ | + | 34 |
| True hor. mot. of ☽ | 32 | 4 |

| | S. | ° | ′ | ″ |
|---|---|---|---|---|
| Long. of ☉ | 1 | 19 | 14 | 53 |
| Diſt. ☽ a ☉ | 6 | 17 | 53 | |
| Doub. diſt. ☽ ☉ | 1 | 5 | 46 | |

| Arguments of the ten firſt equations. | | S. | ° | ′ | Firſt ten equ. + ′ | ″ | — ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| Mean Anom. ☉. | I. | 10 | 8 | 56 | | | 8 | 39 |
| 2 ☽ ☉ + Arg. 1. | II. | 11 | 14 | 42 | 0 | 14 | | |
| 2 ☽ ☉ — Arg. 1. | III. | 2 | 26 | 50 | | | 1 | 2 |
| Arg. 2. — Me. An. ☽. | IV. | 1 | 21 | 14 | 1 | 24 | | |
| Arg. 3. — Me. An. ☽. | V. | 5 | 3 | 22 | | 33 | | |
| 2 ☽ a ☉ + Me. An. ☽. | VI. | 10 | 29 | 14 | | | | 46 |
| 2 ☽ a ☊ — Me. An. ☽. | VII. | 3 | 28 | 6 | | 51 | | |
| Me. An. ☽ — Arg. 1. | VIII. | 11 | 14 | 32 | | | | 11 |
| Long. ☊ — long. ☉. | IX. | 11 | 22 | 6 | | | | 13 |
| ☽ a ☉ — Me. An. ☽. | X. | 8 | 24 | 25 | | 10 | | |
| Sums | | | | | 3 | 12 | 10 | 51 |
| | | | | | | + | 3 | 12 |
| Sum of ten equations | | | | | | — | 7 | 39 |

| | S. | ° | ′ | ″ |
|---|---|---|---|---|
| Mean anomaly of ☽ | 9 | 23 | 28 | 24 |
| | 9 | 23 | 20 | 45 |
| Double firſt equation — | | — | 17 | 18 |
| Anom. ☽ corr. Arg. XI. | 9 | 23 | 3 | 27 |
| Diſt. ☽ a ☉ corr. — | 6 | 17 | 45 | 55 |
| Doub. diſt. ☽ a ☉ corr. | 1 | 5 | 31 | 50 |
| Arg. XII. of evection — | 3 | 12 | 28 | 23 |
| Arg. XIII. of variation | 6 | 22 | 5 | 31 |
| Mean long. of ☊ — | 1 | 11 | 21 | 12 |
| Equat. I. correction of ☊ | | — | 8 | 39 |
| Long. ☊ corr. — | 1 | 11 | 12 | 33 |
| Arg. of lat. and reduction | 7 | 0 | 36 | 58 |
| Arg. IX. + arg. XIII. is arg. lat. II. | 6 | 14 | 11 | |

# C H A P. V.

## *To reduce the obſerved Diſtance of the Moon's Limb from a Star, or from the Sun's Limb to the apparent Diſtance of the Centres, by allowing the Moon's Semidiameter, or the Sum of the Semidiameters of the Sun and Moon; and to clear the apparent Diſtance of the Centres of the Effects of Refraction and Parallax.*

### 1. *To correct the obſerved Diſtance by the Moon's Semidiameter, or the Sum of the Semidiameters of the Sun and Moon.*

CORRECT the obſerved diſtance of the moon's limb from a ſtar by allowing the error of the adjuſtment of the quadrant; and to the diſtance thus corrected add the moon's apparent ſemidiameter, increaſed according to her altitude, if the limb obſerved was that neareſt to the ſtar; but ſubſtract the ſemidiameter, if the limb obſerved was that fartheſt from the ſtar. This gives the apparent diſtance of the moon's centre from the ſtar. But ~~from~~ to the obſerved diſtance of the ſun and moon's neareſt limbs, firſt corrected for the error of the quadrant, ~~ſubſtract~~ add the ſum of the ſemidiameters of the ſun and moon; this gives the apparent diſtance of the centres of the ſun and moon. The ſemidiameter of the ſun is found from table in page 5, and the ſemidiameter of the moon is found from her parallax by table in page 23; as is alſo the augmentation for the degree of altitude. In this example, the mean of the three obſerved diſtances of the ſtar from the moon's remoteſt limb was 51d. 40m. 40ſ. to which adding the error of the adjuſtment of the quadrant, 3m. 20ſ. gives the apparent diſtance correct, 51d. 44m. 0ſ. from which ſubſtracting the moon's ſemidiameter, 15m. 25ſ. becauſe the obſerved limb was that furtheſt from the ſtar, leaves 51d. 28m. 35ſ. the apparent diſtance of the ſtar from the moon's centre.

### 2. *To clear the apparent Diſtance of a Star from the Moon's Centre, or the apparent Diſtance of the Centres of the Sun and Moon, from the Effect of Refraction.*

Correct the obſerved altitude of the ſtar by the error of adjuſtment, if any; and ſubſtract the dip of the horiſon of the ſea, and you have the apparent altitude of the ſtar. From the obſerved altitude of the moon's upper or lower limb, firſt corrected for the error of the quadrant, if any, ſubſtract the dip, and add 16m. if the lower limb was obſerved, but ſubſtract 16m. if the upper limb was obſerved, and you have the apparent altitude of the moon's centre. If the diſtance of the moon was taken from the ſun, add the difference of the dip and 16m. to the obſerved altitude of the ſun's lower limb, corrected for the error of the quadrant if any, and you have the apparent altitude of the ſun's centre. To the apparent altitudes of the ſtar, and of the centres of the ſun and moon, add three times the refractions belonging to thoſe altitudes reſpectively, found from the table in page 1, and you have the altitudes of the ſtar, ſun, and moon increaſed, the complements of which to 90 are their zenith diſtances diminiſhed.

Now add together the logarithm tangents of half the ſum and half the difference of the diminiſhed zenith diſtances of the moon and ſtar, or of the ſun and moon. The ſum, abating 10 from the index, is the tangent of arc the 1ſt.

To the tangent juſt found add the cotangent of half the apparent diſtance of the ſtar from the moon's centre, or the centres of the ſun and moon; the ſum, abating 10 from the index, is the tangent of arc the 2d.

Then to the tangent of double the firſt arc add the conſtant logarithm, 2.0569, and from the ſum ſubſtract the ſine of double the ſecond arc, leaves the logarithm of the number of ſeconds expreſſing the effect of refraction required, which added always to the apparent diſtance of the ſtar from the moon's centre, or of the centres of the ſun and moon, gives the diſtance cleared of refraction.

### *Example of the Computation of the Effect of Refraction.*

| | ° | ′ |
|---|---|---|
| Mean of three obſerved altitudes of the ſtar | 24 | 52 |
| Error of adjuſtment | 0 | 0 |
| Subſtract dip | — | 4 |
| Add three times refraction for altitude 25° | + | 6 |
| Altitude of the ſtar increaſed | 24 | 54 |
| Complement to 90 is zenith diſtance of ſtar diminiſhed | 65 | 6 |
| Mean of three obſerved altitudes of the moon's lower limb | 12 | 18 |
| Error of quadrant | 0 | 0 |
| Subſtract dip | — | 4 |
| Add ſemidiameter of the moon | + | 16 |
| Add three times the refraction for altitude | + | 13 |
| Altitude of the moon's centre increaſed | 12 | 43 |
| Compl. to 90 is zenith diſtance of the moon diminiſhed | 77 | 17 |
| Zenith diſtance of ſtar diminiſhed | 65 | 6 |

Half

| | |
|---|---|
| Half ſum 71° 11′ tangent | 10.4675 |
| Half difference 6° 5′ tangent | 9.0276 |
| Tangent of arc the firſt, 17° 22′ | 9.4951 |
| Cotan. half apparent diſtance of the ſtar from the moon's centre 25° 44′ | 10.3170 |
| Tangent of arc the ſecond, 32° 58′ | 9.8121 |
| Double arc the firſt, 34° 44′ tang. | 9.8409 |
| Conſtant logarithm | 2.0569 |
| Sum | 11.8978 |
| Double arc ſecond, 65° 56′ ſine ſubſtract. | –9.9605 |
| Logarithm of 86″, the effect of refraction | 1.9373 |
| Apparent diſtance of the Virgin's Spike from the moon's centre | 51° 28′ 35″ |
| Add the effect of refraction | + 1 26 |
| Apparent diſt. of the ſtar from the moon's centre, cleared of refraction | 51 30 1 |

### 3. *To clear the apparent Diſtance of a Star from the Moon's Centre, or of the Centres of the Sun and Moon of the Effect of Parallax.*

From the obſerved altitudes of the ſtar, and the moon's upper or lower limb, or the ſun's lower limb, firſt corrected for error of quadrant, ſubſtract the ſum of the dip and refraction from tables in page 1, and add further 16m. to the altitude of the ſun or moon's lower limb, or ſubſtract 16m. from the altitude of the upper limb, gives the true altitude of the ſtar, and of the centres of the ſun and moon; the complements of which to 90d. are their true zenith diſtances.

Then add together into one ſum the tangents of half the ſum and half the difference of the true zenith diſtances, and the cotangent of half the apparent diſtance of the ſtar from the moon's centre, or of the centres of the ſun and moon cleared from refraction; the ſum, abating 20 from the index, is the tangent of arc the ſecond correct, (which is nearly the ſame with arc the ſecond, found above in computing refraction) the ſum of this, and half the apparent diſtance of the ſtar from the moon's centre, if the zenith diſtance of the moon is greater than that of the ſtar; or their difference, if the zenith diſtance of the moon is leſs than that of the ſtar, gives arc the third. To the tangent of arc the third add the coſine of the apparent zenith diſtance of the moon's centre, cleared of refraction, and the logarithm of the moon's horiſontal parallax, expreſſed in minutes and decimals, the ſum, abating 20 from the index, is the logarithm of the number of minutes expreſſing the effect of parallax, in augmenting or contracting the diſtance of the moon from a ſtar, which always ſubſtract from the apparent diſtance of the ſtar from the moon's centre, or of the centres of the ſun and moon, cleared of refraction, except arc the third ſhould be the difference of arc the ſecond, and half the diſtance of the moon and ſtar; and at the ſame time, arc ſecond be greater than the ſaid half diſtance of the moon and ſtar, or ſun, in which caſe add the effect of parallax to the apparent diſtance cleared of refraction, gives the true diſtance of the ſtar from the moon's centre, or of the centres of the ſun and moon, cleared both of refraction and parallax.

| | ° | ′ |
|---|---|---|
| Mean of three obſerved altitudes of ſtar by quadrant | 24 | 52 |
| Error of quadrant —— —— | 0 | 0 |
| Subſtract ſum of dip 4′ and refraction 2′ | — | 6 |
| True altitude of the ſtar —— | 24 | 46 |
| The complement to 90 is the true zenith diſt. of ſtar | 65 | 14 |
| Mean of three obſerved altitudes of the moon's lower limb | 12 | 18 |
| Error of quadrant —— —— | 0 | 0 |
| Subſtract ſum of dip 4′ and refraction 4′ | — | 8 |
| Add ſemidiameter of the moon —— | + | 16 |
| True altitude of the moon's centre —— | 12 | 26 |
| Compl. to 90 is the true zenith diſtance of the moon | 77 | 34 |
| Zenith diſtance of ſtar —— —— | 65 | 14 |

| | | | | |
|---|---|---|---|---|
| Half ſum of zenith diſtances | 71° | 24′ | tang. | 10.4730 |
| Half difference of zenith diſtances | 6 | 10 | tang. | 9.0336 |
| Half diſt. of ſtar from the moon's centre | 25 | 45 | cotang. | 10.3166 |
| Sum, tangent of arc ſecond correct | 33 | 39 | | 9.8232 |
| Sum of arc 2d and ½ diſt. of moon fr. ſtar | 59 | 24 | tang. | 10.2281 |
| Moon's zenith diſtance —— | 77 | 34 | coſine | 9.3330 |
| Moon's horiſontal parallax | 56′ 15″=56′,25 | | log. | 1.7501 |
| Logarithm of effect of parallax | 20,48 =20′ 29″ | | | 1.3112 |

This by the rule is here to be ſubſtracted from 51d. 30m. 1ſ. the apparent diſtance of the ſtar from the moon's centre, cleared of refraction, which gives 51d. 9m. 32ſ. the true diſtance of the ſtar from the moon's centre, cleared both of refraction and parallax.

N. B. If the altitudes of the moon and ſtar are both more than 10d. they may be uſed in theſe computations of refraction and parallax, as taken from the quadrant, only allowing the error of the adjuſtment, if any, and the dip, and the moon's ſemidiameter, to reduce the altitude of the limb to that of the centre; and arc the ſecond may be uſed for arc the ſecond correct, without any ſenſible error, which will ſave ſome trouble in calculation. Four places of figures beſides the index, will be ſufficient in theſe computations.

# C H A P. VI.

## *From the true Diſtance of the Centres of the Sun and Moon reduced from the Obſervation, and the Moon's Latitude found from the Tables, to compute the Difference of Longitude between the Sun and Moon, and thence to find the Moon's true Longitude; or, from the true Diſtance of the Star from the Moon's Centre reduced from the Obſervation, the Star's Latitude, and the Moon's Latitude, found from the Tables, to compute the Difference of Longitude between the Moon and Star; and thence to find the Moon's true Longitude.*

### 1. *From the true Diſtance of the Centres of the Sun and Moon, reduced from the Obſervation, and the Moon's Latitude found from the Tables, to compute the Difference of Longitude between the Sun and Moon, and thence to find the Moon's true Longitude.*

TO the coſine of the diſtance of the centres of the ſun and moon reduced from the obſervation, add 10 in the place of the index, and from the ſum ſubſtract the coſine of the moon's latitude, the remainder is the coſine of the difference of longitude between the ſun and moon, which, added to the ſun's longitude found by the tables, if the moon is to the eaſt of the ſun, or ſubſtracted from the ſun's longitude, if the moon is to the weſt of the ſun, gives the moon's true longitude.

## EXAMPLE.

Let us ſuppoſe the true diſtance of the centres of the ſun and moon reduced from an obſervation to be 73d. 37m. 13ſ. and the moon's latitude, found by the tables, to be 4d. 23m. 36ſ.

| | | |
|---|---|---|
| Coſine of diſtance of moon from ſun | 73° 37′ 13″ | 9.4502521 |
| Add to index | —— —— | 10. |
| | | 19.4502521 |
| Subſtract coſine of the moon's latitude | | 9.9987220 |
| | | 9.4515301 |
| Coſ. of dif. of long. of ſun and moon | 73° 34′ 14″=2S. | 13° 34′ 14′ |

Suppoſe the ſun's longitude to have been computed by the tables 7S. 15d. 22m. 46ſ. and the moon to be to the weſt of the ſun, the difference 2S. 13d. 34m. 14ſ. ſubſtracted from the ſun's longitude, 7S. 15d. 22m. 46ſ. leaves 5S. 1d. 48m. 32ſ. the moon's true longitude.

2. *From the true Diſtance of a Star from the Moon's Centre, reduced from the Obſervation, the Star's Latitude, and the Moon's Latitude, found by the Tables, to compute the Difference of Longitude between the Moon and Star, and thence to find the Moon's true Longitude.*

If the latitudes of the moon and ſtar are both of the ſame denomination, that is to ſay, both north or both ſouth, their complements to 90d. are their diſtances from the neareſt pole of the ecliptic: or if their latitudes are of different denominations, ſubſtract one from 90d. it does not matter which, and add the other to 90d. which gives their diſtances from one of the poles of the ecliptic, which I ſhall call their polar diſtances.

Now take half the difference of the polar diſtances, and half the diſtance of the moon and ſtar reduced from the obſervation. Then add together theſe four logarithms, the ſine of the half diſtance increaſed by the ſaid half difference, the ſine of the half diſtance leſſened by the ſaid half difference, the arithmetical complement of the ſine of the polar diſtance of the ſtar, and the arithmetical complement of the ſine of the polar diſtance of the moon. Half the ſum of theſe four logarithms is the ſine of an arc, which doubled is the difference of longitude between the moon and ſtar; this added to the ſtar's longitude, if the moon is eaſt of the ſtar, or ſubſtracted from the ſtar's longitude, if the moon is weſt of the ſtar, gives the true longitude of the moon in the ecliptic.

In making theſe calculations ſeven places of figures muſt be uſed, beſides the index, and proportion muſt be made for ſeconds, except Gardiner's logarithms be uſed, out of which the logarithms may be taken at ſight, for the neareſt ten ſeconds. The ſtar's latitude and longitude muſt be taken out of table in page 4, and the latter muſt be corrected by table in page 5, and alſo by adding 50⅓ ſ. for every year after 1763.

## EXAMPLE.

|  | ° | ′ | ″ |
|---|---|---|---|
| Diſt. of moon from ſtar, reduced from obſervation | 51 | 9 | 32 |
| Latitude of the Virgin's Spike | 2 | 2 | 9 S. |
| Latitude of the moon | 2 | 39 | 26 S. |
| Polar diſtance of the Virgin's Spike | 87 | 57 | 51 |
| Polar diſtance of the moon | 87 | 20 | 34 |
| Difference of polar diſtance | 0 | 37 | 17 |
| Half difference | 0 | 18 | 38 |
| Half diſtance of the moon from the Virgin's Spike, reduced from the obſervation | 25 | 34 | 46 |

Half

| | ° | ′ | ″ | | |
|---|---|---|---|---|---|
| Half diſt. of moon from ſtar $+\frac{1}{2}$ diff. | 25 | 53 | 24 | ſine | 9.6401282 |
| Half diſt. of moon from ſtar $-\frac{1}{2}$ diff. | 25 | 16 | 8 | ſine | 9.6302925 |
| Pol. diſt. of Virgin's Spike | 87° | 57′ | 51″ | ar. compl. ſin. | 0.0002739 |
| Pol. diſt. of the moon | 87 | 20 | 34 | ar. compl. ſin. | 0.0004672 |
| Sum | | | | | 19.2711618 |
| Half ſum, ſine of | 25° | 36′ | $2\frac{1}{2}$″ | | 9.6355809 |
| Doubled is | 51 | 12 | 5 | diff. of long. of moon and ſtar. | |

| | S. | ° | ′ | ″ |
|---|---|---|---|---|
| Longitude of the Virgin's Spike in table, page 4 | 6 | 20 | 32 | 1 |
| Add correction for May 9, from table, page 5th | | | | + 38 |
| Subſt. 50″ becauſe the year precedes 1763 by 1 year | | | | — 50 |
| Longitude of ſtar correct | 6 | 20 | 31 | 49 |
| To which add the diff. of long. of moon and ſtar found above, 51°12′5″ (becauſe moon is eaſt of ſtar) = | 1 | 21 | 12 | 5 |
| True long. of moon inferred from the obſervation | 8 | 11 | 43 | 54 |

CHAP.

## C H A P. VII. and Laſt.

## *To find the Error of the Ship's Reckoning, and conſequently the true Longitude of the Ship.*

TAKE the difference of the moon's longitude, as inferred from the obſervations by the laſt Chapter, and the moon's longitude computed from the tables by Chap. IV. and, if the moon's diſtance was obſerved from a ſtar, ſay, by the rule of proportion, as the hourly motion of the moon is to the ſaid difference, ſo is 900m. to the error of the ſhip's account in minutes. But, if the diſtance of the moon was obſerved from the ſun, inſtead of the hourly motion of the moon, uſe the difference of the hourly motions of the ſun and moon. The hourly motion of the ſun is contained in table, page 5. Or the error of the account may be found more briefly thus: With the hourly motion of the moon, or the difference of the hourly motions of the ſun and moon, according as the moon's diſtance was obſerved from a ſtar or the ſun, take out a number, called the multiplier, from table, page 25, with which multiply the difference of the moon's longitude inferred from obſervation, and that computed; the product is the error of the ſhip's account of longitude. And if the longitude of the moon computed by the tables, is greater than that inferred from the obſervation, the ſhip is to the eaſt of the longitude by account; but, if leſs, the ſhip is weſt of the longitude by account. When the ſhip is eaſt of the longitude by account, the error of the account is to be added to her eaſt longitude by account, or ſubſtracted from her weſt longitude by account; but when the ſhip is weſt of the longitude by account, the ſaid error is to be ſubſtracted from her eaſt longitude by account, and added to her weſt longitude by account. The ſaid correction may be applied either to the ſhip's longitude by account, on the noon preceding the obſervation, or to the ſame carried on to the next noon, or to any intermediate time, and will give the true longitude of the ſhip at the time propoſed; which was the thing to be found from all the obſervations and calculations.

In the example, the moon's true longitude, inferred from the obſervation, is 8S. 11d. 43m. 54ſ. and the moon's longitude, computed from the tables, from the time aſſumed at Greenwich, according to the ſhip's reckoning, is 8S. 11d. 43m. 25ſ. The difference is 29ſ. and ſay, by the rule of proportion, as 32m. 4ſ. the hourly motion of the moon, found after the computation of the moon's place, is to 29ſ. the ſaid difference, ſo is 900m. to 14m. the error of the ſhip's account. Or, more briefly, multiply 29ſ. by $28\frac{1}{10}$ the multiplier, taken out of table, page 25, with the hourly motion of the moon, 32m. 4ſ. the product, 815ſ. or 14m. nearly, is the error of the ſhip's reckoning; and the moon's longitude computed from tables, being leſs than that inferred from obſervations reduced, the ſhip is weſt of account, and her reckoning by account on the preceding noon having been 7d. 44m. weſt of Greenwich, her true longitude at that time was 7d. 44m.+14m.=7d. 58m. weſt of Greenwich.

Or if it be required to find the longitude of the ſhip at the time of taking the diſtance of the moon from the ſtar, add 14m. to the longitude by account at that time, which was 6d. 54m. weſt; whence the true longitude of the ſhip at that time was 6d. 54m.+14m.=7d. 8m. weſt of Greenwich. Or if it be propoſed to find the longitude of the ſhip on the following noon, or the noon of May 10, add 14m.

to the longitude by account carried on to that time, which is 6d. 26m. weſt; whence the true longitude, May 10, at noon, was 6d. 26m. + 14m. = 6d. 40m. weſt of Greenwich.

The reaſon why the error of the ſhip's reckoning is ſo ſmall in this example, is becauſe it was corrected by an obſervation the night before.

At ſun-riſe we ſaw the Scilly iſlands bearing N.E.b.N. by the compaſs, or 14d. E. of the true north, and diſtant by eſtimation about ſix leagues; and we had made 40½m. of departure = 1d. 3m. of longitude to the eaſtward ſince noon; therefore our longitude by account was 6d. 41m. W. But, by the obſervations of the moon, 14m. is to be added to correct the longitude by account; therefore the true longitude at this time is 6d. 41m. + 14m. = 6d. 55m. W. But by the bearing and eſtimated diſtance, the middle of the Scilly iſlands muſt be 7m. of longitude to the eaſt of the ſhip; and therefore their longitude, as deduced from the obſervations of the moon, is 6d. 55m—7m. = 6d. 48m. W.

At 9 A.M. the light-houſe on St. Agnes, one of the Scilly iſlands, bore N. 8½d. W. by the compaſs, diſtant by eſtimation 5 leagues; and we had made 47 miles departure = 1d. 12m. of longitude to the eaſt ſince noon. Therefore, our longitude by account is 6d. 32m. weſt; or, corrected by the obſervation of the moon, 6d. 32m. + 14m. = 6d. 46m. W. But, by the bearing and eſtimated diſtance, St. Agnes light-houſe was 12m. of longitude to the weſt of the ſhip; therefore its longitude, deduced from the obſervations of the moon, is 6d. 46m. + 12m. = 6d. 58m. W. This longitude differs 10m. from the longitude of the middle of the Scilly iſlands, according to their bearing and eſtimated diſtance at ſun-riſe, tho' it ſhould ſeem, that it ought to agree nearly

with

with it. But this ſmall difference may be eaſily accounted for, if it be conſidered, that theſe iſlands extend near half a degree from eaſt to weſt, and that the ſame part may not appear to be the middle of them at a diſtance at ſea, as does in the charts; not to mention our being in a tide's way, and the difficulty of eſtimating diſtances with exactneſs. But, which-ever of theſe determinations is taken, it will not differ above 18 or 20 minutes of longitude from the beſt charts, which make but 12 miles in this latitude.

Having had a good obſervation, May 10, at noon, determining the latitude of St. Agnes, I ſhall ſet it down, though it be a little deviation from my preſent ſubject. The latitude of the ſhip, by the ſaid obſervation, was 49d. 48m. N. and the light-houſe of St. Agnes at that time bore N. 38d. W. by the compaſs, diſtant by eſtimation five leagues; whence its latitude ſhould be 49d. 56m. N. which is 10m. more than is given to it in Whiſton's Chart of the Channel.

APPENDIX.

# APPENDIX,

*Containing ſome additional Rules, ſerving to find the Moon's right Aſcenſion and Declination, and thence to compute her Altitude; as alſo to compute the Altitude of the Star, ſuppoſing they were not obſerved: and alſo a particular Problem for finding the Longitude from three cotemporary Obſervations only.*

As it may ſometimes happen, though very rarely, that, at the obſervation of the diſtance of the moon from the ſtar, the altitude of the ſtar, and even that of the moon, cannot be taken with ſufficient certainty, I ſhall here ſubjoin the method of computing them.

In order to this it is neceſſary firſt to know their right aſcenſions and declinations, and alſo the right aſcenſion of the ſun at the time. The right aſcenſions and declinations of all the principal ſtars are contained in the table, page 2 and 3; the right aſcenſion of the ſun is to be found from his longitude, by table page 27 and 28. I now proceed to ſhew how the right aſcenſion and declination of the moon may be readily found with ſufficient exactneſs.

### *The Longitude and Latitude of the Moon being given, to find the Right Aſcenſion and Declination.*

This may be done very expeditiouſly from Halley's or Senex's map of the zodiac, or any map of the like kind, containing circles of latitude with their parallels, and circles of declinations with their parallels; or even by a large globe, accurately conſtructed. But leſt the obſerver ſhould be unprovided with theſe helps, I offer him the two following eaſy rules for this purpoſe, which are ſufficiently exact to find the moon's right aſcenſion and declination true to two minutes.

## PREPARATION.

Take out of the tables of the declination of the degrees of the ecliptic, page 26, the declination anſwering to the moon's longitude, and note whether it be north or ſouth. Subſtract three ſigns from the moon's longitude, and take out of the ſame tables the declination correſponding, and alſo note whether it be north or ſouth. Alſo take out of the tables of the right aſcenſion of the degrees of the ecliptic, page 27 and 28, the right aſcenſion anſwering to the moon's longitude.

## RULE I.

### *To find the Moon's Declination.*

To the ſine of the moon's latitude add the coſine of the declination of that point of the ecliptic, whoſe longitude is leſs than the moon's by three ſigns; the ſum, abating 10 from the index, is the ſine of an arc, the ſum of which, and the declination of the point of the ecliptic belonging to the moon's longitude, provided that the moon's latitude and the ſaid declination are of the ſame kind, that is to ſay, both north, or both ſouth; or their difference, if they are of contrary denominations, gives the true declination of the moon, of the ſame kind with the greater.

## RULE II.

### *To find the Moon's right Aſcenſion.*

To the ſine of the moon's latitude add the ſine of the declination of that point of the ecliptic, whoſe longitude is leſs than the moon's by three ſigns, and from the ſum ſubſtract the coſine of the declination of the point of the ecliptic anſwering to the moon's longitude, leaves the ſine of an arc, which add to the right aſcenſion of the point of the ecliptic belonging to the moon's longitude, if the moon's latitude is of the ſame kind with the declination of the point of the ecliptic, whoſe longitude is leſs than the moon's by three ſigns; or ſubſtract it if they are of different kinds; the reſult is the true right aſcenſion of the moon.

## EXAMPLE.

### *Of the Computation of the Moon's Declination and right Aſcenſion from the Longitude and Latitude given.*

I ſhall adapt the example to the time of the obſervations above recited, and ſhall firſt of all compute the moon's right aſcenſion and declination, by which we ſhall be enabled afterwards to compute the altitude of the moon, ſuppoſing it had not been obſerved.

## PREPARATION.

At the time of the obſervation of the diſtance of the Virgin's Spike from the moon, above recited, the moon's longitude was computed by the tables 8 S. 11d. 43m. and latitude 2d. 39m. S. leaving out the ſeconds. By, table p. 26, the declination anſwering to the moon's longitude, 8 S. 11d. 43m. is 22d. 14m. S. Subſtract three ſigns from the moon's longitude, leaves 5 S. 11d. 43m. the declination anſwering to which is 7d. 11m. N, By table, page 27 and 28, the right aſcenſion anſwering to the moon's longitude, 8 S. 11d. 43m. is 250d. 11m.

To

### *To find the Moon's Declination.*

Sine of the moon's latitude 2° 39′ S. ——— 8.66497
Coſine of declination anſwering to longitude 5S. 11° 43′
 or moon's longitude, 8 S. 11° 43′—3 S. 7° 11′ N. 9.99658

Sine of 2° 38′ ——— ——— 8.66155

The ſum of this and 22d. 14m. S. the declination anſwering to the moon's longitude, becauſe the moon's latitude and the ſaid declination are of the ſame kind, is the moon's declination, 24d. 52m. S.

### *To find the Moon's right Aſcenſion.*

Sine of the moon's latitude 2° 39′ S. 8.66497
Sine of declination anſwering to longitude of the moon,
 — 3 ſigns, or 5 S. 11° 43′ 7° 11′ N. 9.09706

17.76203
Subſtract coſ. of declination anſwering to the moon's
 longitude 22° 14′ ——— —9.96645

Sine of 0° 21′ ——— ——— 7.79558

Which ſubſtract from 250d. 11m. the right aſcenſion anſwering to the moon's longitude, becauſe the moon's latitude, and the declination anſwering to the moon's longitude — 3 ſigns, are of contrary denominations, leaves the right aſcenſion of the moon 249d. 50m.

RULE

## RULE III.

*To compute the apparent Altitude of the Moon or a Star, at the Time of the Obſervation of the Diſtance of the Moon from the Star.*

Turn the apparent time, corrected by allowing the error of the watch, as found by the altitude of the ſun, into degrees and minutes, by table, page 3 and 4; and add it to the ſun's right aſcenſion, taken out of table, page 27 and 28, with the ſun's longitude, computed in Chap. IV. The ſum is the right aſcenſion of the mid-heaven nearly. Correct this by the longitude made by the ſhip ſince the taking of the altitude of the ſun in the afternoon, by which the watch was corrected, adding it, if the ſhip has gone to the eaſt, or ſubſtracting it, if ſhe has gone to the weſt, gives the right aſcenſion of the mid-heaven correct; the difference between which, and the right aſcenſion of the moon or ſtar, is their hourly angle, or diſtance from the meridian. If the moon or ſtar's declination is of the ſame denomination with the latitude of the ſhip, ſubſtract it from 90d. but, if it be of the contrary denomination, add it to 90d. and you have the diſtance from the elevated pole. To the coſine of the hourly angle add the cotangent of the latitude of the ſhip; the ſum, abating 10 from the index, is the tangent of arc the firſt, the difference of which, and the diſtance of the moon or ſtar from the elevated pole, is arc the ſecond. To the coſine of arc the ſecond add the ſine of the ſhip's latitude, and from the ſum ſubſtract the coſine of arc the firſt, give the ſine of the true altitude of the moon or ſtar. And to find the apparent altitudes, add the refraction from table, page 1, to the true altitude of the ſtar, and ſubſtract the difference between the refraction, from table, page 1, and the moon's parallax in altitude, from table, page 26, from the moon's true altitude: gives the apparent altitudes of the moon and ſtar.

## EXAMPLE.

### *Of the Computation of the apparent Altitudes of the Moon and Star.*

The apparent time was found 12h. 5m. 35ſ. at the end of Chap. III. which, turned into degrees and minutes by table, page 3 and 4, is 181d. 24m. And, by table, page 27 and 28, the ſun's right aſcenſion anſwering to his longitude, 1S. 19d. 15m. computed in Chap. IV. is 46d. 47m. The ſum is 228d. 11m. the right aſcenſion of the mid-heaven nearly; to which add 17m. of longitude, which the ſhip has made to the eaſt, ſince the altitude of the ſun in the afternoon, by which the watch was corrected, gives 228d. 28m. the right aſcenſion of the mid-heaven correct.

### *To find the apparent Altitude of the Virgin's Spike.*

The declination of the Virgin's Spike, by table, page 2, is 9d. 55m. S. whence the latitude of the ſhip being north, the diſtance of the ſtar from the elevated pole is 99d. 55m. The right aſcenſion of the Virgin's Spike, by table, page 2, is 198d. 10m. the difference of which, and 228d. 28m. the right aſcenſion of the mid-heaven, is the hourly angle of the Virgin's Spike, 30d. 18m.

| | | |
|---|---|---|
| Coſine of hourly angle of Virgin's Spike 30° 18′ | | 9.93621 |
| Cotan. of latitude of ſhip 49° 23′ | — | 9.93329 |
| Tan. of arc the firſt 36° 31′ | — | 9.86950 |

The difference between which and 99d. 55m. the diſtance of the Virgin's Spike from the elevated pole, gives arc the ſecond, 63d. 24m.

| | |
|---|---|
| Coſine of arc the ſecond, 63° 24′ | 9·65104 |
| Sine of latitude of ſhip, 49° 23′ | 9·88029 |
| | 19·53133 |
| Subſtract coſine of arc the firſt, 36° 31′ | —9·90508 |
| Sine of true altitude of the Virgin's Spike, 25° 1′ | 9·62625 |

Add 2m. of refraction at this altitude, by table, page 1, gives apparent altitude of the Virgin's Spike, 25d. 3m. It was obſerved 24d. 52m. or taking off 4m for the dip, 24d. 48m.

### *To find the apparent Altitude of the Moon's Centre.*

The declination of the moon has been computed above, 24d. 52m. S. therefore, the latitude of the ſhip being north, the diſtance of the moon from the elevated pole is 114d. 52m. The right aſcenſion of the moon has been computed above, 249d. 50m. the difference of which, and 228d. 28m. the right aſcenſion of the mid-heaven, is 21d. 22m. the hourly angle of the moon.

| | |
|---|---|
| Coſine of hourly angle of the moon, 21° 22′ | 9·96907 |
| Cotan. of latitude of the ſhip, 49° 23′ | 9·93329 |
| Tangent of arc the firſt, 38° 37′ | 9·90236 |

The difference between which, and 114d. 52m. the diſtance of the moon from the elevated pole, gives arc the ſecond, 76d. 15m.

| | |
|---|---|
| Coſine of arc the ſecond, 76° 15 —— | 9.37600 |
| Sine of latitude of the ſhip, 49° 23′ —— | 9.88029 |
| | 19.25629 |
| Subſtract coſine of arc the firſt, 38° 37′ | —9.89284 |
| Sine of the true altitude of the moon, 13° 21′ | 9.36345 |

From which ſubſtract the difference of 4m. the refraction, by table, page 1, and 55m. the parallax in altitude, by table, page 26, gives the apparent altitude of the moon, 12d. 30m. The altitude of the moon's lower limb was obſerved 12d. 18m. from which ſubſtracting 4m. for the dip, and adding 16m. for the moon's ſemidiameter, the apparent altitude of her centre from the obſervation is 12d. 30m. which happens to agree exactly with that computed.

A PRO-

# A PROBLEM.

*To determine the Longitude at Sea or Land from three cotemporary Obſervations only, namely, the Diſtance of the Moon's Limb from a Star, and the apparent Altitudes of the Moon and Star, provided the Moon be not leſs than two Hours diſtant from the Meridian.*

IT has been ſaid in Chap. II. that four obſervations are generally neceſſary to be made, in order to find the longitude, according to the method deſcribed in the following chapters; namely, an altitude of the ſun, or a bright ſtar, in order to regulate a watch, by the time of which all the obſervations are noted down; the diſtance of the moon's limb from the ſun, or a proper ſtar, and the apparent altitudes of the ſame ſtar, and of the moon's upper or lower limb. It has, however, been remarked in the ſame place, that the neceſſary obſervations are reduced to three, when the diſtance of the moon from the ſun is obſerved; the altitude of the ſun, taken at the ſame inſtant, being ſufficient to determine the time, without the uſe of any other altitude of the ſun, or a ſtar, and even without the aid of a watch. For the ſame reaſon, the altitude of the ſtar, from which the diſtance of the moon's limb is meaſured, being taken at the ſame inſtant, will alſo determine the time with ſufficient exactneſs, provided the horiſon be tolerably enlightened, and the ſtar be at leaſt two hours from the meridian, without requiring the altitude of the ſun, or any other ſtar, and even without the uſe of a watch.

For the very ſame reaſon, the altitude of the moon likewiſe, taken at the ſame inſtant with the obſervation of her diſtance from the ſtar, will ſerve equally to determine the time, provided ſhe be at leaſt two hours from the meridian, and the horiſon be ſufficiently enlightened, ſo that her altitude may be taken with ſome exactneſs. But as the moon's right aſcenſion and declination, which are both neceſſary to be known in this caſe, are continually varying, and cannot be aſſumed, near enough, from the eſtimated time of the day, and the longitude of the ſhip by account, as the declination of the ſun may, this caſe requires another proceſs, and demands a particular method of computing the longitude, diſtinct from that explained in the preceding pages, which hath not, that I know of, been yet thought of, or, at leaſt, not recommended to the public for this purpoſe. I have therefore propoſed it as a problem, and now proceed to give the ſolution. I ſhall only firſt remark, that this method, as it requires only the three eſſential obſervations taken at the ſame inſtant, ſo it may often be of very great uſe, eſpecially where the watch, which the obſervers uſe, is ſo indifferent as not to be depended upon within one, or even two minutes, for the ſpace of ſome hours; and that, in many caſes, it may be full as exact as the general method, which I have hitherto propoſed, as the altitude of the moon, eſpecially if not very high, may be often taken at ſea in the night, by the help of her own light illuminating the horiſon, to almoſt as great a degree of exactneſs, as the altitude of the ſun in the day-time; whereas the altitudes of ſtars, which do not lie in the ſame vertical with the moon, cannot be taken with the ſame certainty, the horiſon under them being not enlightened in the ſame manner.

*The*

### *The following Steps muſt be obſerved in the Solution of the Problem propoſed.*

1. Aſſume the apparent time of the obſervation as near as you can, which may be done very well, within half an hour, either by common watches, or the glaſſes of the ſhip; only take care to allow for the ſhip's change of longitude, at the rate of four minutes for every degree you have made ſince they were laſt corrected, adding this correction if you have been going eaſtward, or ſubſtracting it if you have been going weſtward. To the time ſo aſſumed, add or ſubſtract your longitude from Greenwich, turned into time, by table, page 3 and 4, according as you are to the weſt or eaſt of Greenwich. To this time compute the ſun's longitude, and the moon's longitude, latitude, &c. as in Chap. IV.

2. From the three given obſervations, the diſtance of the ſtar from the moon, and the altitudes of the moon and ſtar, and the moon's horiſontal parallax, find the true diſtance of the ſtar from the moon's centre, by correcting the obſerved diſtance of the ſtar from the moon's limb, for the moon's ſemidiameter, and for refraction and parallax, according to Chap. V.

3. With the true diſtance of the ſtar from the moon's centre thus found, and the moon's latitude computed, find the difference between the longitudes of the moon and ſtar, and thence the moon's true longitude, according to Chap. VI.

4. From the moon's longitude thus found, and latitude computed above, find her right aſcenſion and declination, by the two rules after Chap. VII. with the help of the tables, page 26, 27, and 28; and from the ſun's longitude, com-

puted above, find his right aſcenſion, by table, page 27 and 28. From the obſerved altitude of the moon's lower limb ſubſtract the ſum of dip and refraction; add 16m. for the moon's ſemidiameter, and add the parallax in altitude, taken out of table, page 25, with the moon's apparent altitude and horiſontal parallax: or from the obſerved altitude of the moon's upper limb, ſubſtract the ſum of dip, refraction, and 16m. for the moon's ſemidiameter, and add the parallax in altitude, and you have the true altitude of the moon's centre, the complement of which to 90d. is the zenith diſtance of the moon. With this, and the moon's declination, and the latitude of the ſhip at the time, find the moon's diſtance from the meridian, according to Chap. III. which add to, or ſubſtract from, the moon's right aſcenſion, found above, according as ſhe is to the weſt or eaſt of the meridian, gives the right aſcenſion of the mid-heaven, from which ſubſtract the ſun's right aſcenſion, found above; the remainder, converted into time by table, page 3 and 4, is the apparent time required. In ſtrictneſs, the time thus found ſhould be corrected at the rate of 1ſ. upon every 6m. of the difference between the ſaid time and the time aſſumed, to be ſubſtracted if the firſt is greateſt, and added if the ſecond is greateſt. The computation is to be performed according to Chap. III.

5. Take the difference between this time and the time at firſt aſſumed, and, by the rule of proportion, as 60m. of time is to this difference, ſo is the moon's hourly motion (found after computing the moon's place) to a number of minutes and decimals of a minute, which add to, or ſubſtract from, the moon's longitude computed to the aſſumed time, reduced to Greenwich, according as the time found by the altitude of the moon, exceeds or falls ſhort of the time aſſumed, and you have the longitude of the moon agreeable to the tables, at the time found by the altitude of

the

the moon, reduced to Greenwich, according to the ſhip's account.

6. By comparing this longitude of the moon, reſulting from computation, with that inferred from the obſervation, find the error of the ſhip's account, and thence the true longitude of the ſhip, according to Chap. VII.

## EXAMPLE.

*Of the Determination of the Longitude from three cotemporary Obſervations of the Diſtance of a Star from the Moon's Limb, and of the Altitudes of the Moon and Star, according to the Problem.*

I ſhall make uſe of ſome of the ſame obſervations as I employed in the illuſtration of the general method.

May 9, 11h. 33m. 42ſ. by the watch, the diſtance of the Virgin's Spike from the moon's remoteſt limb was meaſured 51d. 40m. 40ſ. but 3m. 20ſ. is to be added for the error of the adjuſtment of the quadrant. At the ſame inſtant, the altitude of the ſtar from the apparent horiſon of the ſea was taken, 24d. 52m. and the altitude of the moon's lower limb above the ſame, 12d. 18m. both free from any error of the quadrant, but including the dip and refraction. The latitude of the ſhip was 49d. 23m. and the longitude by account, 6d. 53m. weſt of Greenwich.

Article I. I ſhall aſſume the time to be 11h. 40m. P.M. the longitude from Greenwich, at this time, by account, is 6d. 53m. W.=27m. 32ſ. of time, by table, page 3 and 4; this, added to the time aſſumed, 11h. 40m. P.M. gives the aſſumed time reduced to Greenwich, 12h. 7m. 32ſ. P.M.

Hence the ſun's longitude, computed by the tables, is 1S. 19d. 13m. 48ſ. The equation of time — 3m. 54ſ. the mean time at Greenwich, by aſſumption, 12h. 3m. 38ſ. P. M. Hence the moon's longitude, computed by the tables, is 8 S. 11d. 29m. 6ſ. the latitude 2d. 38m. 17ſ. S. the moon's horiſontal parallax 56m. 15ſ. horiſontal ſemidiameter 15m. 21ſ. and hourly motion 32m. 4ſ.

Art. II. From the obſervations given, the true diſtance of the ſtar from the moon's centre is found, cleared of refraction and parallax, 51d. 9m. 32ſ. in Chap. V.

Art. III. With the true diſtance of the ſtar from the moon's centre, 51d. 9m. 32ſ. and the moon's latitude, 2d. 38m. 17ſ. S. find the difference between the longitudes of the moon and ſtar, and thence the moon's true longitude, according to Chap. VI. making the computation, the difference of longitude between the moon and ſtar will come out 51d. 12m. 4ſ. differing only 1ſ. from what was found in Chap. VI. though the moon's latitude is taken above a minute leſs in this computation than it was in that; the reaſon of which is, that the latitudes of the moon and ſtar are both of the ſame kind, and ſo nearly agree together. But even if the difference of their latitudes is greater, provided it does not exceed the limits of the table in page 4, an error of 1m. 2m. or even 3m. in the moon's latitude, (which we may poſſibly be ſometimes ſubject to in this computation, whether from the imperfection of the tables in this reſpect, or an error in the aſſumption of the time) can be of no prejudice in the reſult.

The longitude of the Virgin's Spike, by table, page 4, corrected by table, page 5, and alſo by ſubſtracting 50ſ. is 6S. 20d. 31m. 49ſ. to which add the difference of longitude between the moon and ſtar, found above, 51d. 12m. 4ſ. =1S. 21d. 12m. 4ſ. becauſe the moon was eaſt of the ſtar, gives the true longitude of the moon inferred from the obſervation, 8S. 11d. 43m. 53ſ.

Art. IV. From the moon's longitude, juſt found, 8S. 11d. 44m. and latitude computed before, 2d. 38m. S. find her right aſcenſion and declination by the two rules after Chap. VII. with the help of the tables, page 26, 27, and 28. The moon's declination will be found 24d. 51m. S. within a minute, as it is in the example to the rules, and her right aſcenſion, as in the example there, 249d. 50m. With the ſun's longitude, 1S. 19d. 14m. find his right aſcenſion, by table, page 27 and 28, 46d. 46m. From the obſerved altitude of the moon's lower limb, 12d. 18m. ſubſtract the ſum of dip 4m. and refraction 4m. and add 16m. for the moon's ſemidiameter; alſo add the parallax, 55m. anſwering to the altitude, 12d. 18m. taken out of table, page 26, with the moon's horiſontal parallax, 56m. hence the true altitude of the moon's centre is 13d. 21m. and her zenith diſtance, 76d. 39m. Her declination being found, 24d. 51m. S. and the latitude being 49d. 23m. N. the diſtance of the moon from the elevated pole is 90d.+24d. 51m.=114d. 51m. and the colatitude 90d.—49d. 23m.=40d. 37m.

### *Computation of the apparent Time from the obſerved Altitude of the Moon.* Vide Chap. III.

| | ° | ′ |
|---|---|---|
| Zenith diſtance of the moon —— —— | 76 | 39 |
| Diſt. of the moon from the elevated pole | 114 | 51 |
| Colatitude —— —— | 40 | 37 |
| Sum of zenith diſt. of moon, polar diſt. and colatitude | 232 | 7 |
| Half ſum —— —— | 116 | 3 |

| | ° | ′ | |
|---|---|---|---|
| Arith. compl. of ſine of colatitude | 40 | 37 | 0.18642 |
| Arith. compl. of ſine of pol. diſt. of moon | 114 | 51 | 0.042219 |
| Sine of half ſum —colat.=116°3′— 40°37′= | 75 | 26 | 9.98581 |
| Sine half ſum—pol. diſt.=116°3′—114°51′= | 1 | 12 | 8.32103 |
| Sum of four logarithms —— | | | 18.53545 |
| Half ſum, ſine of 10° 40½′ —— | | | 9.26772 |

| | ° | ′ |
|---|---|---|
| Doubled is diſt. of moon from meridian | —21 | 21 |
| Which ſubſtract from the moon's right aſcenſion, the moon being eaſt of the meridian, —— | 249 | 50 |
| Leaves right aſcenſion of mid-heaven —— | 228 | 29 |
| Subſtract the ſun's right aſcenſion, found above, | —46 | 46 |
| Remainder —— —— | 181 | 43 |

| | h. | m. | ſ. |
|---|---|---|---|
| Apparent time, by table, page 3 and 4, | 12 | 6 | 52 P. M. |
| But this exceeding 11h. 40m. P. M. the time aſſumed, by 27m. which contains 6m. four times, ſubſtract —— | | | 4 |
| Apparent time correct from altitude of moon | 12 | 6 | 48 P. M. |

Art. V. The difference between the apparent time thus found, 12h. 6m. 48ſ. and the time aſſumed, 11h. 40m. being 26m. 48ſ. ſay, as 60m. : 26m. 48ſ. :: $\overset{\text{hor. mot. ☽}}{\text{32m. 4ſ.}}$ : 14m. 20ſ. which add to 8S. 11d. 29m. 6ſ. the moon's longitude, computed from the tables, becauſe the time computed from the altitude of the moon exceeds the time aſſumed, gives the longitude of the moon from computation correct, 8S. 11d. 43m. 26ſ.

Art. VI. The longitude of the moon juſt found, 8S. 11d. 43m. 26ſ. is leſs than that inferred from the obſervation in Art. III. 8S. 11d. 43m. 53ſ. by 0m. 27ſ. which comes out the ſame within 2ſ. as in the example in Chap. VII. The error of the ſhip's account will therefore be found, as in the ſequel of that Chapter, 14m. the ſhip being ſo much to the weſt of her account; whence her true longitude, at any aſſigned time between the noons of May 9 and 10, is eaſily found, as is exemplified in the latter part of the ſame Chapter.

## *A conciſe Method of finding the Latitude, from two obſerved Altitudes of the Sun, with the Interval of Time given by a common Watch.*

THE common practice of navigation, being incapable of giving the longitude with any certainty, requires, on that account, a more exact knowledge of the latitude; and it is generally ſuppoſed, that this can be ſufficiently determined, at all times, from meridian obſervations of the ſun. It may indeed be thus inferred, to more than a ſufficient degree of exactneſs, by the uſe of that invaluable inſtrument, the Hadley's quadrant, if no clouds or fogs intervene at the time. But what are we to do in this latter caſe? The meridian obſervation being only that of a ſingle inſtant, or, at the moſt, of a few minutes, if a cloud ſhould happen to come at that time, even though it paſs off again preſently, it may either prevent the obſervation, or, at leaſt, render it very doubtful; for, without the obſerver can ſee the ſun both riſe and fall, or, at leaſt, find him continue in a manner ſtationary for ſome minutes, he cannot be ſure that he has obtained the meridian or greateſt altitude.

To prevent theſe inconveniencies, the mathematicians have propoſed a problem, to find the latitude from two obſerved altitudes of the ſun, with the interval of time meaſured by a common watch. By this method, provided the two altitudes can be obtained between the hours of nine in the morning and three in the afternoon, with a proper interval of time between them, the latitude may be determined nearly, as exact as by the meridian obſervation; and as in cloudy weather it affords an incomparably greater chance of ſucceſs, than the meridian obſervation only, it cannot but be of the greateſt uſe, perhaps next in value to the method of finding the longitude. It is therefore to be hoped, that every diligent mariner will practice this improvement, as occaſions may require, eſpecially as it is attended with very little trouble, either on the part of the obſervations or the computations. I need not obſerve, how nearly the art of practical navigation would be perfected by the addition of this more general method of finding the latitude, to the method of finding the longitude, explained in the preceding treatiſe.

The following method of calculation is taken, for the moſt part, from a paper of Dr. Pemberton's in Part II. of the 51ſt Volume of the Philoſophical Tranſactions for 1760, and is more expeditious and convenient, than that by Harriſon's logarithmic ſolar tables, publiſhed in 1759, as it requires, beſides the common tables of logarithms, only a table of logarithmic verſe-ſines, and a table of natural ſines, both of which are to be found in Sherwin's exact tables of logarithms, which ought alſo to be uſed in the computations of the longitude, as being the moſt exact and compleat tables extant.

I have ſubjoined ſome cautions that ought to be uſed in the choice of the times of the obſervations, to enſure the ſucceſs of the computations.

## PREPARATION.

If both the altitudes of the ſun were taken in the morning, or both in the afternoon, ſubſtract the time ſhewn by the watch at the firſt obſervation, from the time ſhewn by the watch at the ſecond obſervation: but if one was taken in the forenoon, and the other in the afternoon, add 12 hours to the latter, from which ſubſtract the time of the forenoon obſervation; the difference is the elapſed time. Turn the elapſed time into parts of a circle, at the rate of 15d. to 1h. and 15m. to 1m. of time, &c. or more briefly, by the table, page 3, and to the degrees and minutes thus found, add the longitude made by the ſhip in the interval between the obſervations, if it has been ſailing eaſterly, or ſubſtract it, if it has been ſailing weſterly; the ſum, or difference, is the elapſed angle, of which take the half.

Correct both altitudes of the ſun in the following manner. From the obſerved altitude of the ſun's lower limb, corrected for the error of the quadrant, if any, ſubſtract the ſum of the dip of the ſea and refraction, by tables, page 1, and add 16m. for the ſun's ſemidiameter: or from the obſerved altitude of the ſun's centre, corrected for error of quadrant, if any, ſubſtract the ſum of the dip and refraction, and you have the true altitude of the ſun's centre; the complement of which to 90d. is the zenith diſtance of the ſun.

*N. B.* The meridian altitudes of the ſun ought always to be corrected in this manner for computing the latitude; and in very hazy weather, when the limbs of the ſun are very ill defined, it is more exact to obſerve the altitude of the centre.

Take the ſun's declination for the day at noon, as in computing the latitude from a meridian obſervation; by correcting, as in that caſe, the declination contained in your ephemeris, or printed tables, for the difference of longitude from London, to which thoſe tables are adapted. Laſtly, caſting up your log-book, find the latitude of the ſhip by account at noon, which is the ſuppoſed latitude, to be made uſe of in the following calculations, in order to find the true latitude.

Now add together the ſine of half the ſum of the zenith diſtances, the ſine of half the difference of the zenith diſtances, the arithmetical complement of the coſine of the ſun's declination, the arithmetical complement of the coſine of the ſuppoſed latitude, and the arithmetical complement of the ſine of the half-elapſed angle; the ſum of theſe five logarithms, abating ten from the index, is the ſine of the half time from noon, or the middle time between the two obſervations from noon, in parts of a circle. The difference of this and half the elapſed angle, is the diſtance of the obſervation of the greateſt altitude from noon, whether it be before or after noon.

Next add together the verſed ſine of the diſtance of the greateſt altitude from noon, the coſine of the ſun's declination, and the coſine of the ſuppoſed latitude; the ſum of theſe three logarithms, abating 23 from the index, is the logarithm of a number, which, added to the natural ſine of the greateſt obſerved altitude of the ſun's centre, corrected as above for dip, refraction, &c. taken out of Sherwin's tables, is the natural ſine of the ſun's meridian altitude; whence the meridian altitude of the ſun is found by the ſame tables, and the latitude is thence found in the uſual manner.

*N. B.* If a table of natural ſines was uſed, conſiſting only of ſix or five places of figures, when greateſt, inſtead of ſeven, as Sherwin's, then, inſtead of abating 23 from the index of the ſum of the three logarithms above, 24 or 25 muſt be abated.

If the diſtance of the obſervation of the greateſt altitude from noon, found by the calculation in parts of a circle, be turned into time, at the rate of 1h. to 15d. and 1m. of time to 15m. &c. or, more briefly, by table, page 3, and be compared with the time given by the watch, it will ſhew how much the watch is too faſt or too ſlow for apparent time.

## EXAMPLE.

*Of the Computation of the Latitude from two obſerved Altitudes of the Sun, with the intermediate Time meaſured by a Watch.*

Jan. 22, 1761, at 9h. 24m. 21ſ. A. M. by a watch, the apparent altitude of the ſun's lower limb from the horiſon of the ſea, was obſerved 13d. 44m. and at 10h. 56m. 38ſ. 20d. 16m. There is 2m. to be ſubſtracted for the error of the adjuſtment.

## PREPARATION.

Subſtract 9h. 24m. 21ſ. the time of the firſt obſervation, from 10h. 56m. 38ſ. the time of the ſecond obſervation, the difference, 1h. 32m. 17ſ. is the elapſed time. This turned into parts of a circle, at the rate of 1h. to 15d. and 15m. to 1m. of time, &c. or, more briefly, by the reverſe of table, page 3, gives 23d. 4m. from which ſubſtract 3m. of longitude, which the ſhip has made to the weſtward, in the interval between the obſervations, leaves 23d. 1m. the elapſed angle, half of which is 11d. 30m.

From 13d. 44m. the firſt altitude of the ſun obſerved, ſubſtract 2m. for the error of the quadrant, and likewiſe ſubſtract the ſum of the dip 4m. and refraction 4m. according to tables, page 1, and add 16m. for the ſun's ſemidiameter, gives the true altitude of the ſun's centre, 13d. 50m. the complement of which to 90d. or 76d. 10m. is the zenith diſtance of the ſun.

In like manner, from 20d. 16m. the ſecond obſerved altitude of the ſun's lower limb, ſubſtract 2m. for the error of the quadrant, and ſubſtract the ſum of the dip 4m. and refraction 2m. and add 16m. for the ſemidiameter of the ſun, gives 20d. 24m. the true altitude of the ſun's centre, the complement of which to 90d. or 69d. 36m. is the zenith diſtance of the ſun.

The ſun's declination this day at noon at London is 19d. 34m. S. but being 6d. 40m. weſt of London, and the ſun's daily variation of declination decreaſing, being 14m. ¼m. ſhould be ſubſtracted on this account, which is of no conſequence.

I ſhall ſuppoſe the latitude to be 48d. 30m. N.

*Calculation of the Latitude from two obſerved Altitudes, with the intermediate Time meaſured by a Watch.*

| | | | |
|---|---|---|---|
| Half ſum of the zenith diſtances | 72° 53′ | ſine | 9.98032 |
| Half difference of zenith diſtances | 3 17 | ſine | 8.75795 |
| Sun's declination, 19° 34′ | | arithmet. compl. of coſine | 0.02583 |
| Suppoſed latitude, 48° 30′ | | arithmet. compl. of coſine | 0.17873 |
| Half elapſed angle, 11° 30′ | | arithmet. compl. of ſine | 0.70034 |
| Sine of angle of middle time from noon = 26° 5′ | | | 9.64317 |

| | | |
|---|---|---|
| The difference of this and half elapſed angle, | 11° 30′ | |
| is diſtance of greateſt altitude from noon, | 14° 35′ | |
| verſed ſine — — | | 8.50809 |
| Sun's declination, 19° 34′ coſine — | | 9.97417 |
| Suppoſed latitude, 48° 30′ coſine — | | 9.82126 |
| | | 28.30352 |
| Subſtract from index — | | 23 |
| Logarithm of natural number | 201150 | 5.30352 |
| Natural ſine of greateſt altitude of ſun's centre — 20° 24′ by Sherwin's tables — | 3485720 | |
| | 3686870 | |
| Sum is natural ſine of the ſun's meridian altitude — | ° ′<br>21 38 | |
| Add ſun's declination — | 19 34 S. | |
| Complement of latitude — | 41 12 | |
| Latitude — — | 48 48 | |
| It was obſerved — | 48 45 | |

Diſtance of greateſt altitude from noon found above, 14° 35′ in time, by table, page 3, 58m. 20ſ. whence the time is 11h. 1m. 40ſ. A. M. But the time of the watch was 10h. 56m. 38ſ. Hence the watch is 5m. 2ſ. too ſlow for apparent time.

### *The following Cautions are proper to be uſed in chooſing out the Times of the Obſervations.*

1. The two obſervations muſt be always taken between 9 in the morning, and 3 in the afternoon; but the nearer they are to noon, the better, provided there be a ſufficient interval between them. The following directions will ſhew what interval is proper.

2. If both obſervations are in the forenoon, the interval of time between them muſt not be much leſs than half the diſtance of the firſt obſervation from noon.

3. If both obſervations are in the afternoon, the interval between them muſt not be much leſs than the diſtance of the firſt obſervation from noon.

4. If one obſervation is in the forenoon, and the other in the afternoon, the interval of time between them muſt not exceed 4½ hours.

5. If the ſun's meridian zenith diſtance be conſiderably leſs than the latitude of the place, then the obſervation muſt be taken proportionably nearer to noon. Thus, if the latitude be double the ſun's meridian zenith diſtance, the firſt of two obſervations taken in the forenoon muſt not be before 9½ A. M. nor the ſecond before 10¾ A. M. or the firſt of two taken in the afternoon, muſt not be after 1¼ P. M. nor the ſecond after 2½ P. M. Or if one obſervation be taken in the forenoon, and the other in the afternoon, that in the forenoon muſt not be taken before 9½ A. M. nor muſt the interval between that and the afternoon obſervation be above 3½ hours. If the latitude be three times the ſun's meridian zenith diſtance, the firſt of two obſervations taken in the forenoon muſt not be before 10 A. M. nor the ſecond before 11 A. M. or the firſt of two taken in the afternoon muſt not be after 1 P. M. nor the ſecond after 2 P. M. Or, if one be taken in the forenoon, and the other in the afternoon, that in the morning muſt not be before 10 A. M. and the interval between them muſt not be above 3 hours. If the latitude be five times the ſun's meridian zenith diſtance, the firſt of two obſervations taken in the forenoon muſt not be before 10½ A. M. nor the ſecond before 11¼ A. M. or the firſt of two taken in the afternoon muſt not be after 0¾ P. M. nor the ſecond after 1½ P. M. or, if one be taken in the forenoon, and the other in the afternoon, the morning one muſt not be before 10½ A. M. nor the

interval between them be above $2\frac{1}{4}$ hours. If the latitude be twelve times the ſun's meridian zenith diſtance, the firſt of two obſervations taken in the forenoon muſt not be before 11 A. M. nor the ſecond before $11\frac{1}{2}$ A. M. or the firſt of two taken in the afternoon muſt not be after $0\frac{1}{2}$ P. M. nor the ſecond after 1 P. M. or, if one be taken in the forenoon, and the other in the afternoon, the morning one muſt not be before 11 A. M. nor the interval between them be above $1\frac{1}{2}$ hours. But if the ſun's meridian zenith diſtance be ſtill leſs in proportion to the latitude, it will be neceſſary to take the obſervations ſo much nearer to the noon, that the advantage of the method will be very much diminiſhed.

If the above cautions are uſed, the latitude computed will be at leaſt five times nearer the truth than the latitude ſuppoſed; and therefore the error of the latitude computed will not be above $\frac{1}{4}$th of the difference between them; from whence a judgment may be formed, whether it will be neceſſary or not to repeat the calculation over again with the latitude found, inſtead of the latitude firſt ſuppoſed.

Cautions the 2d, 3d, and 4th, are given to prevent the unavoidable errors in taking the altitudes of the ſun, or in the meaſure of the elapſed angle by the watch, from producing a greater error than themſelves in the latitude computed. They are founded upon theſe two theorems; 1. That the error produced in the latitude computed is to the error in either of the altitudes, as the ſine of the ſun's azimuth at the taking of the other altitude, to the ſine of the difference, or ſum of the azimuths, according as they are of the ſame or different ſides of the meridian. 2. That the error in the latitude computed is to the error in the meaſure of the interval of time, turned into parts of the equator, as the product of the ſines of the two azimuths, and the coſine of the latitude, to the product of the ſquare of the radius, and the ſine of the difference, or ſum of the azimuths.

The error in the meaſure of the interval of time by a common watch, is moſt to be apprehended ; but where a watch is uſed, whoſe rate of going is very regular, there the cautions 2d, 3d, and 4th, need not be obſerved ſo very ſtrictly, and a leſs interval of time may be admitted between the obſervations, when made both in the afternoon, or both in the forenoon ; or a longer interval may be admitted between one obſervation made in the forenoon, and the other made in the afternoon. The time of the watch ſhould be eſtimated to $\frac{1}{4}$ m. or leſs if it can be done, if it has no ſecond hand.

Caution 5th, is neceſſary to be obſerved, in order that the error in the ſuppoſed latitude may be diminiſhed five times in the latitude computed, and is taken from the eſtimation of the error of the calculation, made in the abovementioned paper in the Philoſophical Tranſactions.

I have only one remark more to add, that the latitude thus found is that at noon, provided the change of the ſhip's latitude between the obſervations and noon be tolerably uniform, and the meridian ſun be not very near the zenith ; the error ariſing in the calculations from the neglect of the ſhip's change of latitude, in this caſe, very nearly compenſating itſelf, and carrying on the latitude to the time of noon, as will be found upon trial. Therefore it is only neceſſary to allow for the ſhip's change of longitude between the obſervations, as is done in the precepts above.

## *Some Remarks on the proper Length of the Log-Line.*

AS the deſire of imparting my beſt aſſiſtance to the diligent mariner was my motive to undertake the foregoing work, ſo the ſame reaſon induces me to recommend to his ſerious notice the great importance of the adjuſtment of the log-line to its true length. Until this be done generally, not only will our ſhips be incapable of making the beſt dead reckonings poſſible in the common method, which will, for many reaſons, be always proper, notwithſtanding the introduction of the method of finding the longitude, but alſo it will be impoſſible to make the reckonings of any two ſhips, even when ſailing the ſame voyage, and in company with each other, to agree tolerably together; for while one ſhip has a line of 42 feet between knot and knot to a glaſs of 28 ſeconds; another, one of 42 feet to a half-minute glaſs; and another one of 48 feet to a glaſs of 28 ſeconds; all which proportions are very commonly uſed, their accounts muſt differ as much from one another, as moſt of them do from the truth; for, as only one can be right, all the reſt muſt conſequently be wrong.

It is not difficult to ſee that the want of a fixed ſtandard in this particular carries a very evil influence along with it upon the practice of navigation, ſince a ſhip making any particular voyage hereby loſes the greateſt part of the advantage which it might otherwiſe receive from the journals of ſhips who have gone the ſame tract before. For, of what great uſe can it be to me, to be informed, that a ſhip has made a certain number of degrees between any two ports, as long as I am uncertain whether its log-line was divided at the rate of 42 or of 50 feet to a half-minute glaſs? I am here left in an uncertainty to the amount of $\frac{1}{5}$ or $\frac{1}{6}$ of the length of my whole voyage; for I am uncertain, whether I ought to make the ſame quantity of longitude as that ſhip did, or $\frac{1}{5}$ or $\frac{1}{6}$ more or leſs.

It may perhaps be urged, that the difference of longitude between any two places may be taken from books of navigation and correct charts, without recurring to ſhip's journals at all. To this I anſwer, that though the longitudes of all places could be found in theſe books or charts to a ſufficient exactneſs, yet, unleſs my own log-line be properly divided, I cannot expect to make a true and correct reckoning. But I muſt alſo obſerve, that the longitudes of places are far from being laid down generally in books and charts, with that degree of exactneſs that it was to be wiſhed they were, for the benefit of navigation. Thoſe longitudes only, of places which have been found from aſtronomical obſervations, or which have been referred to other places, ſo ſettled, by accurate trigonometrical ſurveys, are to be looked upon as certain. The longitudes of all other places, not ſo ſettled, muſt depend either on the uncertain maps of countries not at all, or, at leaſt, not well ſurveyed; or on the journals of ſhips, the uncertainty of both which, eſpecially in conſiderable diſtances, is too apparent to need any pointing out. As therefore the difficulty of procuring aſtronomical obſervations to be made in all parts of the globe will always oblige us to depend upon the runs of ſhips, or maps of countries, for the longitudes of many places, it is plain, that the preſent uncertain manner of dividing the log-line as well prevents us from knowing, with that certainty we otherwiſe might, the longitudes of thoſe places, which can be known only from ſhips runs, as alſo from keeping a correct reckoning, even when we know with certainty the longitudes both of the port we depart from, and that we are bound to.

There is another argument, which adds much ſtrength to the foregoing ones, and greatly enforces the neceſſity of a uniform and correct length of the log-line on board of all ſhips; that in many parts of the ocean, eſpecially between the tropics and near moſt headlands, there are conſiderable currents, which muſt conſequently introduce a freſh error into the reckoning; and if this error ſhould happen to combine with that already produced by a wrong length of the log-line, as it may, as well as not, it is not eaſy to ſay how far the total error of the reckoning might go, or to what inconveniencies or dangers the ſhip might be expoſed on that account. But if the juſt and proper length of the log-line was uſed on board of all ſhips, they would be then liable only to the errors of the currents themſelves; and even theſe, as far as they are conſtant and regular, might be found out and aſcertained from the journals of ſeveral ſhips, which would then agree much nearer with one another.

After inſiſting ſo ſtrongly on the neceſſity of adjuſting the knots of the log-line to a proper length, it is time that I ſhould mention what that length is. This, by the teſtimony of all mathematicians, is 50 or 51 feet to a glaſs which runs out in 30 ſeconds, or half a minute. But if the glaſs take a longer or ſhorter time to run out, the diſtance of the knots ſhould be made longer or ſhorter in the ſame proportion, according to the following Table.

*A Table*

## *A Table of the Length of the Knots of the Log-line for different Glaſſes.*

| Seconds of Glaſs. | Length of Knots. | |
|---|---|---|
| | Feet. | In. |
| 24 | 40 | 0 |
| 25 | 41 | 8 |
| 26 | 43 | 4 |
| 27 | 45 | 0 |
| 28 | 46 | 8 |
| 29 | 48 | 4 |
| 30 | 50 | 0 |
| 31 | 51 | 8 |
| 32 | 53 | 4 |
| 33 | 55 | 0 |
| 34 | 56 | 8 |
| 35 | 58 | 4 |
| 36 | 60 | 0 |

The true length of the knots of the log-line here delivered, was firſt laid down by our countryman, Mr. Richard Norwood, in his Seaman's Practice, in the year 1636. For having carefully meaſured the diſtance from London to York, and reduced it to the arch of the meridian, and having alſo found the difference of latitude of thoſe two cities by aſtronomical obſervations, he thence inferred a degree of a great circle of the earth to contain 367200 Engliſh feet, or about 69½ Engliſh ſtatute miles, inſtead of 60, which was the common eſtimation before his time. Hence he concludes a geographical mile, or minute of a great circle of the earth, which is $\frac{1}{60}$ of a degree, to contain 6120 feet, and therefore, that the length of the knots of a log-line for a half-minute glaſs ſhould be 51 feet, which is the ſame part of a geographical mile, or 6120 feet, as half a minute is of an hour, namely, $\frac{1}{120}$th. But he adds, becauſe it is ſafer to have the reckoning rather before the ſhip, than after it; therefore 50 feet may be taken as the proper length of each knot, which I have here accordingly followed.

Before Mr. Richard Norwood's accurate menſuration, the length of the knots of the log-line was made 42 feet for a half-minute glaſs; and, notwithſtanding the meaſures of the degrees of the earth, as well as daily experience ſhew it to be too ſhort, yet it is uſed by many to this day. This diviſion of the log-line was founded on a ſuppoſition, that a degree of a great circle of the earth conſiſts of 60 miles, each containing 5000 Engliſh feet; whence a minute of a great circle, or a geographical mile, ſhould contain 5000 feet; and the 120th part of 5000 feet, or $41\frac{2}{3}$, or, in round number, 42 feet, ſhould therefore be the length of each knot. But as a degree of a great circle of the earth is found to contain $69\frac{1}{2}$ Engliſh miles, the length of the knots of the log-line ought to be increaſed to 50 or 51 feet.

I ſhall only add, that though many, through prejudice, ſtill retain the erroneous diviſion of 42 feet, yet I could never hear one tolerable argument brought in defence of it. For my own part, I can affirm, that I found the true diviſion of 50 feet here propoſed, to anſwer very nearly to the obſervations of the ſhip's latitude, both in my voyage to St. Helena, and in my voyage on my return, when without the tropics; for within the tropics, and in the courſe of the trade winds, there are conſtant and conſiderable currents, which ſeem to tend in the ſame direction with thoſe winds, and moſt probably derive their origin from them. On the other hand, what journals of ſhips I have had an opportunity to inſpect, which have made long runs to the eaſtward, and have uſed too ſhort a diviſion of the log-line, I have found to reckon the longitude 10 or 12 degrees too far to the eaſtward upon the making of land, as one might naturally expect from the cauſe of error here pointed out.

## *Directions for obſerving the Beginning and Ending of an Eclipſe of the Moon, and an Immerſion or Emerſion of the Satellites of Jupiter.*

THOUGH the method of finding the longitude by diſtances of the moon from the ſun and fixed ſtars is both ſufficiently exact for general uſe, and may be equally uſed at ſea and land, yet it cannot but be an advantage to have it in our power to practiſe every method of finding the longitude, whether of a ſhip at ſea, or of any port at land.

The beginning and ending of an eclipſe of the moon is very eaſily obſerved; and being compared with the times calculated, taken from an exact ephemeris, will determine the longitude of a ſhip at ſea, where the obſervation is made within a degree; the difference between the apparent times of the obſervations at the ſhip, and thoſe calculated in the ephemeris, ſhewing the longitude of the ſhip in time, reckoned from the meridian to which the computations of the ephemeris are adapted.

The obſervations muſt be made by the help of a watch, corrected from an altitude of the ſun or a ſtar, according to the rules given in the preceding treatiſe. But if an eclipſe of the moon ſhould be obſerved at any place at land, whoſe longitude we deſire to know, this may be found more exactly by comparing the obſervation with a correſponding one, made at ſome other place at land, whoſe longitude is known.

The beginning and ending of an eclipſe of the moon may be obſerved very well with the naked eye; but if any teleſcope is uſed, it muſt be one that has a great deal of light, and does not magnify much. Thoſe called night glaſſes may be very conveniently uſed for this purpoſe, in which caſe I ſhould adviſe placing a circular aperture at the object end, about half or $\frac{1}{3}$ of the ſize of the common aperture.

The ſhadow begins to come upon the moon on the eaſt ſide, and goes off on the weſt ſide. The firſt obſcuration that comes upon the moon, called the penumbra, is not perfectly dark; but after a few minutes, the true and darker ſhadow will begin to make its appearance upon the moon's limb, in the place which lies immediately behind the penumbra. At the ending of the eclipſe the true ſhadow goes off firſt, and the penumbra follows it. If the obſerver notes the time of the appearance and diſappearance of the penumbra, or falſe ſhadow, as well as of the darker and true ſhadow, it will appear that he has not miſtaken the former for the latter, as they are apt to do, who are not uſed to the obſervation.

If the eclipſe be total, the immerſion into, and emerſion out of, total darkneſs, are two other obſervations to be made, and will equally ſerve to determine the longitude.

The immerſions and emerſions of Jupiter's ſatellites afford the beſt general method known for determining the longitudes of places at land, and could they be likewiſe obſerved at ſea, as there is room to hope they may, by the help of the marine chair, the longitude might thence be determined, as often as ſuch obſervations were obtained.

A refracting teleſcope of ten feet, or a reflecting teleſcope of one foot at leaſt, will be neceſſary for obſerving theſe eclipſes, though a refractor of 15 feet, and a reflector of 18 inches, or two feet, would anſwer ſtill better.

In general, the immerſions only are viſible, before the oppoſition of Jupiter to the ſun; and, after the oppoſition, the emerſions only, the body of Jupiter hiding the other phænomenon. This is always the caſe with reſpect to the firſt ſatellite; but ſometimes the immerſions and emerſions of the other ſatellites, eſpecially the remoter ones, are both viſible. The immerſions and emerſions before the oppoſition happen on the weſt ſide of Jupiter, as after the oppoſition they happen on the eaſt ſide: only if an aſtronomical refracting teleſcope be uſed, conſiſting of two convex glaſſes, the appearances will be inverted, and the eclipſes will ſeem to happen on the eaſt ſide before the oppoſition, and on the weſt ſide after the oppoſition.

At the immerſions and emerſions, which happen within a few days of Jupiter's oppoſition to the ſun, the ſatellites ſeem to touch his body; but at all other times they fall into, or come out of the ſhadow at ſome diſtance from his limb, which is greater, the further he is from the oppoſition, and the nearer to the quadrature with the ſun. Thus the greateſt diſtance of the 1ſt ſatellite from Jupiter's limb, at the eclipſes, in the quadratures, is a little more than a ſemidiameter of Jupiter; of the 2d, not quite two ſemidiameters; of the 3d, near three ſemidiameters; and of the 4th, five ſemidiameters. But as it is uſeful for diſtinguiſhing the ſatellite which is to immerge into the ſhadow from the reſt, or as a direction whereabouts to look for the ſatellite which is to emerge out of the ſhadow, to know nearly the diſtance it ſhould be at from Jupiter's limb, I have added the following Table for this purpoſe, which may always be depended upon within a tenth part of the whole, the general form of it not admitting of a greater degree of preciſion, on account of the excentricity of the orbits of Jupiter and the earth.

It ſhould be carefully noted, that the apparent diſtances in this table are thoſe at the regular eclipſes, namely, at the immerſions before the oppoſition, and the emerſions after the oppoſition; but at the emerſions which are viſible before the oppoſition, and at the immerſions which are viſible after the oppoſition, the diſtances of the ſatellites from Jupiter's limb will be leſs than is ſet down in the table, by a quantity which bears the ſame proportion to Jupiter's diameter, as the duration of the eclipſe does to the longeſt durations of the eclipſes when the ſatellites are in the nodes. The greateſt durations of the eclipſes of the firſt, ſecond, third and fourth ſatellites are 2h. 16m. 2h. 54m. 3h. 34m. and 4h. 48m. reſpectively.

*A Table of the apparent Diſtance of the Satellites of Jupiter from his Limb at the time of the Eclipſes, for every tenth Day of Jupiter's Diſtance from the Oppoſition or Conjunction.*

| Diſt. of Jupiter from oppoſition of ⊙. | Diſt. of the ſatellites from Jupiter's limb at the eclipſes, in ſemidiameters of Jupiter and decimal parts. | | | | Diſt. of Jupiter from conjunction with ⊙. | Diſt. of the ſatellites from Jupiter's limb at the eclipſes, in ſemidiameters of Jupiter and decimal parts. | | | |
|---|---|---|---|---|---|---|---|---|---|
| Days. | 1ſt ſat. | 2d ſat. | 3d ſat. | 4th ſat. | Days. | 1ſt ſat. | 2d ſat. | 3d ſat. | 4th ſat. |
| 10 | 0, 20 | 0, 33 | 0, 50 | 0, 85 | 10 | 0, 15 | 0, 25 | 0, 35 | 0, 55 |
| 20 | 0, 40 | 0, 66 | 1, 05 | 1, 66 | 20 | 0, 30 | 0, 45 | 0, 70 | 1, 25 |
| 30 | 0, 60 | 0, 95 | 1, 50 | 2, 65 | 30 | 0, 40 | 0, 67 | 1, 05 | 1, 70 |
| 40 | 0, 75 | 1, 20 | 1, 90 | 3, 35 | 40 | 0, 55 | 0, 90 | 1, 40 | 2, 50 |
| 50 | 0, 90 | 1, 40 | 2, 25 | 3, 95 | 50 | 0, 70 | 1, 00 | 1, 80 | 3, 20 |
| 60 | 1, 00 | 1, 60 | 2, 50 | 4, 40 | 60 | 0, 80 | 1, 25 | 2, 00 | 3, 50 |
| 70 | 1, 05 | 1, 70 | 2, 66 | 4, 70 | 70 | 0, 90 | 1, 40 | 2, 25 | 3, 95 |
| 80 | 1, 10 | 1, 75 | 2, 75 | 4, 85 | 80 | 1, 00 | 1, 55 | 2, 45 | 4, 33 |
| 90 | 1, 10 | 1, 75 | 2, 75 | 4, 85 | 90 | 1, 05 | 1, 66 | 2, 60 | 4, 60 |
| 100 | 1, 10 | 1, 70 | 2, 70 | 4, 80 | 100 | 1, 10 | 1, 75 | 2, 70 | 4, 80 |

The diſtance of the ſatellites from Jupiter's limb in the foregoing table, are to be meaſured either in a line with Jupiter's equator, or longer axis, or in a line parallel thereto; or, which is the ſame thing, to his belts; for the ſatellites generally appear a little to the north or ſouth of this line.

During the ſpace of ſix years, while Jupiter is paſſing from the aſcending to the deſcending nodes of the ſatellites, as from the beginning of 1760 to the beginning of 1766, the ſatellites are eclipſed to the north of the equator, departing to the greateſt diſtance from thence at the middle of this period. Thus, at this preſent time, or the beginning of 1763, the 1ſt ſatellite is eclipſed $\frac{1}{4}$th of Jupiter's ſemidiameter, and the 2d about half his ſemidiameter to the north of his equator, and the 3d almoſt in a line with his north pole; the 4th goes north of his pole, and therefore at preſent is not eclipſed at all, nor will be all this year.

For the like ſpace of ſix years more, while Jupiter is paſſing from the deſcending to the aſcending nodes of the ſatellites, as from the beginning of 1766 to the beginning of 1772, the ſatellites will be eclipſed to the ſouth of Jupiter's equator, departing to the greateſt diſtance from thence at the middle of this period, as in 1769. And thus every ſix years the eclipſes happen alternately to the north and ſouth of Jupiter's equator.

The firſt and ſecond ſatellites are moſt uſeful for finding the longitudes of places, the tables of the firſt never erring more than 1m. of time, and thoſe of the 2d not more than 4m. Therefore, if the time of the total immerſion or firſt emerſion of either of theſe ſatellites, corrected from an altitude of the ſun or a ſtar, according to the rules in Chap.

III. of the preceding treatiſe, be compared with the time ſet down in an exact ephemeris, the difference will ſhew the difference of longitude in time from the meridian of the ephemeris, which is turned into degrees and minutes, at the rate of 15d. to 1h. and 15m. to 1m. of time, &c. But if a correſponding obſervation can be obtained, made in any place whoſe longitude is known, the longitude will be found independently of any error of the tables.

I ſhall conclude this ſubject with pointing out a method of taking altitudes at land with Hadley's quadrant, whence the latitude may be found, and the time of the day computed, as from obſervations made at ſea.

Prepare ſome ſhallow veſſel, and pour water, quickſilver, or, which would be ſtill better, ſome thick oil or treacle into it, and place it near ſome window within a room, ſheltered as much as poſſible from the wind, and move the index of the quadrant till the ſun or ſtar in the heavens is brought down by reflection to appear conjoined to the reflected image of the ſun or ſtar in the veſſel, holding a dark glaſs cloſe before the eye, in order to darken both images of the ſun. Then half the angle that the index points at, if the quadrant is rightly adjuſted; or the half of the numbers on the quadrant, firſt corrected for the error of the adjuſtment, if any, is the apparent altitude of the ſun or ſtar. From which ſubſtract the refraction, according to table, page 1, and you have the true altitude, the complement of which to 90d. is the zenith diſtance, with which compute the latitude or time in the common manner. The quadrant may be adjuſted, or the error of the adjuſtment found by any ſtreight object, which is not leſs than a quarter of a mile off. If the altitude of the ſun or ſtar be above 45d. they muſt be taken by the back obſervation.

## *To find the Latitude from the apparent Meridian Altitude of a Star obſerved at Sea.*

FROM the apparent altitude of the ſtar obſerved above the horiſon of the ſea, ſubſtract the ſum of the dip and refraction, according to the tables in page 1, and you have the true altitude of the ſtar, the complement of which to 90d. is the zenith diſtance; with which, and the ſtar's declination, taken out of table page 2 and 3, find the latitude in the very ſame manner as you would do from the ſun.

### EXAMPLE.

May 9, 1762, at night, I obſerved the meridian altitude of the Virgin's Spike 30d. 48½m. I ſubſtract the ſum of the dip 4m. and refraction 2m. which leaves the true altitude of the Virgin's Spike 30d. 48½m. and therefore the zenith diſtance is 59d. 17½m. The declination of the Virgin's Spike, by table, page 2, is 9d. 54m. S. which, ſubſtracted from the zenith diſtance, 59d. 17½m. leaves the latitude 49d. 23½m. N. Near an hour afterwards, by the meridian altitude of Arcturus, 61d. 6m. I found the latitude only 1m. greater. The ſhip had not made any northing or ſouthing between the obſervations, and the latitude by account carried on from the noon but one before, for the noon before it was cloudy, was 49d. 17m.

The example here given ſhews the great uſe that may often be made of this method of finding the latitude; for we had no obſervation of the ſun for the latitude on the noon before, whence our latitude by account muſt be very uncertain;

tain; and at day-break, a few hours after finding the latitude from the altitudes of theſe two ſtars, we diſcovered the Scilly Iſles.

## *To find the Latitude from the apparent Meridian Altitude of the Moon obſerved at Sea.*

From the obſerved meridian altitude of the moon's lower limb, ſubſtract the ſum of the dip and refraction, by tables, page 1. and add 16m. for the moon's ſemidiameter; or, from the obſerved altitude of the moon's upper limb ſubſtract the ſum of the dip, refraction, and 16m. for the moon's ſemidiameter; or, from the obſerved altitude of the moon's centre ſubſtract the ſum of the dip and refraction only; gives the altitude of the moon's centre correct, to which add the parallax of altitude, taken out of table, page 26, gives the true altitude of the moon's centre, the complement of which to 90d. is the moon's zenith diſtance. The preſent horiſontal parallax of the moon, with which the table is to be entered, may be taken out of an ephemeris; or, if one containing it be not at hand, the mean horiſontal parallax, 57m. may be uſed, as the error ariſing from hence will never exceed 4m.

Next, the moon's preſent declination muſt be found. For this purpoſe, firſt take the time of the moon's paſſing the meridian out of an ephemeris, and the daily difference of the ſame; and ſay, as 24h. more the ſaid difference, is to the longitude of the ſhip, reckoned from the meridian of the ephemeris, turned into time by table, page 3 and 4, ſo is the ſame daily variation to a number of minutes, which add to the time of the moon's paſſing the meridian in the ephemeris, if you are to the weſt of that meridian, or ſubſtract if you are to the eaſt of it, and you have the correct time of the moon's paſſing the meridian of the ſhip. To this add or ſubſtract your longitude from the meridian of the ephemeris, turned into time, according as you are to the weſt or eaſt of that meridian, and you have the time of the moon's paſſing the meridian of the ſhip, reduced to the time of the meridian of the ephemeris. Then ſay, as 24 hours is to the time juſt found, ſo is the moon's daily variation of declination, taken out of the ephemeris, to the variation of declination from the noon of the ephemeris to the preſent time nearly; which add to the moon's declination in the ephemeris for the noon before, if the declination is increaſing, or ſubſtract if it is decreaſing, and you have the moon's preſent declination very nearly. This may be further corrected in the following manner. Take out of the ephemeris the moon's declination for the noon but one before, the noon before, the noon after, and the noon but one after; take the ſum of the firſt and laſt declinations, and alſo the ſum of the two middle declinations; and take the difference of theſe two ſums, and $\frac{1}{4}$th of the difference, and ſay, as 24 hours is to the correct time of the moon's paſſing the meridian, reduced to the meridian of the ephemeris found above; ſo is $\frac{1}{4}$th of the difference of the two ſums to a firſt number. Say again, as 24h. is to the correct time of the moon's paſſing the meridian, reduced to the meridian of the ephemeris, ſo is the firſt number, juſt found, to a ſecond number: take the difference of the firſt and ſecond numbers, and add it to the moon's declination found nearly above, if the ſum of the two middle declinations, found above, is greater than the ſum of the two extreme declinations; elſe ſubſtract it, and you have the moon's true declination; with which and the moon's zenith diſtance, found above from obſervation, find the latitude as from the ſun by the common rules.

The correction of the moon's declination here exhibited may ſometimes amount to 10m. when the declination is great, which may ſeem too much to be neglected; but if the declination is under 10d. the correction will be inconſiderable, and need not be applied at all.

It will be proper to compute the apparent time of the moon's paſſing the meridian of the ſhip before-hand, in order to be prepared for the obſervation of the meridian altitude, the rule for which is given in the directions above. For the ſame reaſon it would be neceſſary to compute the apparent time of a ſtar's paſſing the meridian before-hand, when it is propoſed to obſerve its meridian altitude for finding the latitude. This is done by ſubſtracting the preſent right aſcenſion of the ſun from the right aſcenſion of the ſtar; the remainder, turned into time by table, page 3 and 4, is the apparent time of the ſtar's paſſing the meridian.

## EXAMPLE.

*Of the Calculation of the Latitude from the meridian Altitude of the Moon's Centre obſerved at Sea, March* 5, 1762, *at Night,* 61d. $0\frac{1}{2}$m.

I ſubſtract the ſum of the dip 4m. and refraction $\frac{1}{2}$m. there remains 60d. 56m. the altitude of the moon's centre corrected; to which I add 29m. the moon's parallax in altitude, the horiſontal parallax of the moon being at this time 60m. and I have the true altitude of the moon's centre 61d. 25m. whence the zenith diſtance is 28d. 35m.

By the Abbè de la Caille's ephemeris for ten years, the moon paſſes the meridian at Paris, March 5, at 7h. 58m. P. M.

P. M. and March 6, at 8h. 58m. P. M. whence the daily difference is 60m. The longitude of the ſhip was 17d. 1m. weſt of Greenwich, or 19d. 21m. weſt of Paris, which, turned into time, is 1h. 17m. Therefore ſay, as 24h.+60m. or 25h. is to 1h. 17m. :: ſo is 60m : to 3m. nearly, which added to 7h. 58m. the time of the moon's paſſing the meridian at Paris, becauſe the ſhip is in longitude weſt from Paris, gives 8h. 1m. P. M. the time of the moon's paſſing the meridian of the ſhip. To this add 1h. 17m. the longitude reckoned from Paris in time, the ſum is 9h. 18m. the time of the moon's paſſing the meridian of the ſhip, reduced to the time of the meridian of Paris. Then ſay, as 24h. is to 9h. 18m. ſo is 73m. the moon's daily variation of declination, from March 5 to March 6, by the ephemeris, to 28m. which ſubſtract from 27d. 20m. the moon's declination March 5 at noon, by the ephemeris, becauſe the declination is decreaſing, leaves 26d. 52m. the moon's declination nearly.

To correct it, take out of the ephemeris the moon's declination on the preceding noon, 27d. 20m. N. the following noon, 26d. 7m. N. the noon but one before, 26d. 47m. and the noon but one after, 23d. 4m. the ſum of the two middle declinations is 53d. 27m. and of the two extreme declinations, 49d. 51m. The difference is 3d. 36m. $\frac{1}{4}$th of which is 54m. Then ſay, as 24h. : is to 9h. 18m. the time of the moon's paſſing the meridian of the ſhip, reduced to Paris time :: ſo is 54m. : to a firſt number 21m. Again, as 24h. : is to 9h. 18m. : ſo is the firſt number 21m. : to a ſecond number 8m. The difference of the firſt number 21m. and the ſecond number 8m. is 13m. which add to 26d. 52m. the moon's declination found nearly above, becauſe the ſum of the two middle declinations is greater than the ſum of the two extreme declinations, and you have the moon's true declination, 27d. 5m. N. This ſubſtracted from 28d. 35m. the moon's zenith diſtance, inferred above from the obſervation, leaves the latitude of the ſhip 1d. 30m. S. which is only 2m. leſs than the latitude by account, carried on from the meridian altitude of the ſun at noon.

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## EXAMPLE.

*Of a Calculation of the Longitude from Obſervations of the Diſtance of the Moon from Antares, taken at Sea, May* 13, 1762, *in the Morning, in Sight of the Lizard Lights.*

## OBSERVATIONS.

May 13, 1762, at 1h. 47m. 54ſ. A. M. per watch, the apparent altitude of the bright ſtar of the Harp from the horiſon of the ſea was taken, 75d. 12m. The dip of the ſea is 5m. and the error of the quadrant is 2m. to be added to the obſervation. At this time the Lizard lights bore N. 63d. W. diſtant by eſtimation 13 miles. But the latitude of the Lizard being 49d. 57m. N. and its longitude 5d. 43m. weſt of the Royal Obſervatory at Greenwich, the latitude of the ſhip is 49d. 51m. N. and its longitude 5d. 25m. weſt of Greenwich.

Here follow five obſervations of the diſtance of Antares, or the Scorpion's Heart, from the moon's eaſtern and remoteſt limb, together with the time ſhewn by the watch, and the correſponding altitudes of the ſtar, and of the moon's lower limb, obſerved at the ſame time. There is 1m. 50ſ. to be added to the diſtances of Antares from the moon's limb, for the error of the adjuſtment of the quadrant. But the altitudes of the moon and ſtar are only to be corrected by ſubſtracting 4m. on account of the dip of the horiſon.

| May 13, 1762. time per watch. | | | Obſ. diſt. of Antares fr. ☽'s remoteſt limb. | | | Obſ. alt. of ☽'s lower limb. | | Obſ. alt. of Antares. | |
|---|---|---|---|---|---|---|---|---|---|
| H. | M. | S. | D. | M. | S. | D. | M. | D. | M. |
| 1 | 55 | 45 | 43 | 45 | 25 | 8 | 49 | 11 | 58 |
| 2 | 0 | 50 | 43 | 46 | 35 | 9 | 9 | 11 | 45 |
| 2 | 5 | 15 | 43 | 48 | 10 | 9 | 26 | 11 | 18 |
| 2 | 11 | 5 | 43 | 51 | 0 | 9 | 49 | 11 | 0 |
| 2 | 16 | 30 | 43 | 53 | 40 | 10 | 2 | 10 | 44 |
| Mean of times. | | | Mean diſt. | | | Mean alt. of ☽'s lower limb. | | Mean alt. of Antares. | |
| 2 | 5 | 53 | 43 | 48 | 50 | 9 | 27 | 11 | 21 |

### *Computation of the Time by the Altitude of the bright Star of the Harp.* See Chap. III.

Its right aſcenſion at this time, by table, page 3, is 277d. 13m. and its declination 38d. 34m. N.

| | ° | ′ |
|---|---|---|
| Obſerved altitude of bright ſtar of the Harp | 75 | 12 |
| Add for error of quadrant — | + | 2 |
| Subſtract 5 for the dip, the refraction being 0 | — | 5 |
| True altitude of ſtar — — | 75 | 9 |
| Subſtract from — — — | 90 | 0 |
| True zenith diſtance of ſtar — — | 14 | 51 |
| Diſt. of ſtar from elevated or north pole =90°—38° 34′= | 51 | 26 |
| Colatitude =90°—49° 51′= — — | 40 | 9 |
| Sum — — — | 106 | 26 |
| Half ſum — — | 53 | 13 |

Arith.

| | ° | ′ | |
|---|---|---|---|
| Arith. compl. of ſine of colatitude | 40 | 9 | 0 19058 |
| Arith. compl. of ſine of polar diſtance | 51 | 26 | 0.10686 |
| Sine of half ſum —colat.=53°13′— 40° 9′= | 13 | 4 | 9.35427 |
| Sine half ſum—pol. diſt.=53°13′— 51°26′= | 1 | 47 | 8.49304 |
| Sum of four logarithms — | | | 18.14475 |
| Half ſum — — | | | 9.07237 |
| Is ſine of — | 6° | 47′ | |
| | | 2 | |
| | 13 | 34 | |
| Doubled is horary angle, or diſtance of Lyra from the meridian to the eaſt; therefore ſubſtract it from the right aſcenſion of Lyra | 277 | 13 | |
| Gives right aſcenſion of mid-heaven | 263 | 39 | |

The watch being about half an hour too ſlow for the ſun, and the time ſhewn by the watch at taking the altitude of Lyra, being 1h. 47m. 54ſ. the apparent time is about 2h. 18m. A. M. or, in aſtronomical reckoning, May 12, 14h. 18m. P. M. to this add 22m. for 5d. 25m. of longitude weſt of Greenwich, gives the apparent time reduced to the meridian of Greenwich nearly, May 12, 14h. 40m. P. M. to which time the ſun's longitude by computation is 1S. 22d. 13m. Hence, by table, page 27, the ſun's right aſcenſion is 49d. 47m. which ſubſtracted from 263d. 39m. the right aſcenſion of the mid-heaven found above, leaves 213d. 52m. for the apparent time in parts of the equator, which, by table, page 3 and 4, gives the apparent time 14h. 15m. 28ſ. But the time by the watch was 13h. 47m. 54ſ. therefore the watch is 27m. 34ſ. too ſlow for the ſun; which is confirmed by ſeveral other altitudes of Lyra, and of other ſtars, and alſo by altitudes of the ſun taken in the afternoon before, and the morning after the obſervation of the diſtance of the moon from Antares.

The ſhip did not go above half a mile between the obſervation of the altitude of Lyra, and the mean time of the obſervation of the diſtances of the moon from Antares. The mean of the times of thoſe obſervations by the watch is 2h. 5m. 53ſ. to which, 27m. 34ſ. being added, by which the watch is too ſlow for the ſun, gives 2h. 33m. 27ſ. A.M. or, May 12, 14h. 33m. 27ſ. P.M. in aſtronomical reckoning, for the apparent time of the mean of the diſtances of Antares from the moon. To this add 21m. 40ſ. for 5d. 25m. longitude reckoned weſt of Greenwich, turned into time, and we have the apparent time reduced to Greenwich, May 12, 14h. 55m. 7ſ. P.M.

Hence computing, according to Chap. IV. the ſun's longitude is 1S. 22d. 14m. 7ſ. the equation of time —4m. 0ſ. to be ſubſtracted from the apparent time at Greenwich, 14h. 55m. 7ſ. leaves 14h. 51m. 7ſ. the mean time at Greenwich, to which computing, according to Chap. IV. the moon's longitude comes out 9S. 20d. 9m. 3ſ. her latitude 4d. 55m. 17ſ. ſouth; the horiſontal parallax 54m. 42ſ. the apparent ſemidiameter of the moon, augmented according to her altitude, 14m. 58ſ. the hourly motion of the moon 30m. 5ſ. and the multiplier of the difference between the moon's longitude computed, and that inferred from the obſervations, $29\frac{9}{10}$.

The next thing to be done is to allow for the ſemidiameter of the moon, refraction, and parallax, in order to reduce the obſerved diſtance of the ſtar from the moon's limb, to the true diſtance of the ſtar from the moon's centre, according to Chap. IV.

1. To 43d. 48m. 50ſ. the mean of the 5 obſerved diſtances of Antares from the moon's remoteſt limb, I add 1m. 50ſ. for the error of the adjuſtment of the quadrant, and ſubſtract 14m. 58ſ. the apparent ſemidiameter of the moon; whence the apparent diſtance of the ſtar from the moon's centre is 43d. 35m. 42ſ.

2. To allow for refraction and parallax, the obſerved altitude of the moon's centre being near 10d. and that of the ſtar being above 10d. I make uſe of them as taken from the quadrant, only ſubſtracting 4m. for the dip, according to the remark at the end of Chap. V. which makes the calculation ſomewhat more compendious, as follows:

From 9d. 27m. the mean of the five obſerved altitudes of the moon's lower limb, I ſubſtract 4m. for the dip of the horiſon, and add 15m. for the moon's ſemidiameter; whence the apparent altitude of the moon's centre is 9d. 38m. and the apparent zenith diſtance 80d. 22m. and from 11d. 21m. the mean of the obſerved altitudes of the ſtar, ſubſtracting 4m. for the dip, there remains 11d. 17m. the apparent altitude of the ſtar; whence the apparent zenith diſtance of the ſtar is 78d. 43m.

| | | |
|---|---|---|
| Half ſum of zenith diſtances of the moon and ſtar 79° 32′ | tangent | 10.7334 |
| Half differences of zenith diſtances 0° 49′ | tangent | 8.1539 |
| Tangent of arc the firſt, 4° 25′ | — | 8.8873 |
| Half apparent diſtance of ſtar from the moon's centre, 21° 48′ | — — cotan. | 10.3980 |
| Tangent of arc the ſecond, 10° 55′ | — | 9.2853 |

Sum

The ſhip did not go above half a mile between the obſervation of the altitude of Lyra, and the mean time of the obſervation of the diſtances of the moon from Antares. The mean of the times of thoſe obſervations by the watch is 2h. 5m. 53ſ. to which, 27m. 34ſ. being added, by which the watch is too ſlow for the ſun, gives 2h. 33m. 27ſ. A.M. or, May 12, 14h. 33m. 27ſ. P.M. in aſtronomical reckoning, for the apparent time of the mean of the diſtances of Antares from the moon. To this add 21m. 40ſ. for 5d. 25m. longitude reckoned weſt of Greenwich, turned into time, and we have the apparent time reduced to Greenwich, May 12, 14h. 55m. 7ſ. P.M.

Hence computing, according to Chap. IV. the ſun's longitude is 1S. 22d. 14m. 7ſ. the equation of time —4m. 0ſ. to be ſubſtracted from the apparent time at Greenwich, 14h. 55m. 7ſ. leaves 14h. 51m. 7ſ. the mean time at Greenwich, to which computing, according to Chap. IV. the moon's longitude comes out 9S. 20d. 9m. 3ſ. her latitude 4d. 55m. 17ſ. ſouth; the horiſontal parallax 54m. 42ſ. the apparent ſemidiameter of the moon, augmented according to her altitude, 14m. 58ſ. the hourly motion of the moon 30m. 5ſ. and the multiplier of the difference between the moon's longitude computed, and that inferred from the obſervations, $29\frac{9}{10}$.

The next thing to be done is to allow for the ſemidiameter of the moon, refraction, and parallax, in order to reduce the obſerved diſtance of the ſtar from the moon's limb, to the true diſtance of the ſtar from the moon's centre, according to Chap. IV.

1. To 43d. 48m. 50ſ. the mean of the 5 obſerved diſtances of Antares from the moon's remoteſt limb, I add 1m. 50ſ. for the error of the adjuſtment of the quadrant, and ſubſtract 14m. 58ſ. the apparent ſemidiameter of the moon; whence the apparent diſtance of the ſtar from the moon's centre is 43d. 35m. 42ſ.

2. To allow for refraction and parallax, the obſerved altitude of the moon's centre being near 10d. and that of the ſtar being above 10d. I make uſe of them as taken from the quadrant, only ſubſtracting 4m. for the dip, according to the remark at the end of Chap. V. which makes the calculation ſomewhat more compendious, as follows:

From 9d. 27m. the mean of the five obſerved altitudes of the moon's lower limb, I ſubſtract 4m. for the dip of the horiſon, and add 15m. for the moon's ſemidiameter; whence the apparent altitude of the moon's centre is 9d. 38m. and the apparent zenith diſtance 80d. 22m. and from 11d. 21m. the mean of the obſerved altitudes of the ſtar, ſubſtracting 4m. for the dip. there remains 11d. 17m. the apparent altitude of the ſtar; whence the apparent zenith diſtance of the ſtar is 78d. 43m.

| | | |
|---|---|---|
| Half ſum of zenith diſtances of the moon and ſtar 79° 32′ | tangent | 10.7334 |
| Half differences of zenith diſtances 0° 49′ | tangent | 8.1539 |
| Tangent of arc the firſt, 4° 25′ | — | 8.8873 |
| Half apparent diſtance of ſtar from the moon's centre, 21° 48′ — — | cotan. | 10.3980 |
| Tangent of arc the ſecond, 10° 55′ | — | 9.2853 |

Sum

| | | |
|---|---|---|
| Sum of arc 2d and half diſtance of moon from ſtar 32° 43′ | tang. | 9.8078 |
| Moon's zenith diſtance 80° 22′ | coſine | 9.2236 |
| Moon's horiſontal parallax 54′ 42″=54′, 7 | log. | 1.7380 |
| Logarithm of effect of parallax 5′, 88=5′ 53″ | | 0.7694 |

To be ſubſtracted by the rule, page 42, from the apparent diſtance of the ſtar from the moon's centre.

### *Computation of Refraction.*

| | | |
|---|---|---|
| Double arc the firſt, 8° 50′ | tangent | 9.1914 |
| Conſtant logarithm | | 2.0569 |
| Sum | | 11.2483 |
| Double arc the ſecond, 21° 50′ | ſine ſubſtract. | —9.5704 |
| Logarithm of 47″, the effect of refraction | | 1.6779 |

From 43d. 35m. 42ſ. the apparent diſtance of the ſtar from the moon's centre, ſubſtract the effect of parallax —5m. 53ſ. and add the effect of refraction, +47ſ. and you have the true diſtance of Antares from the moon's centre very nearly, 43d. 30m. 36ſ. There remains only to be applied the little correction of the effect of parallax, the rule for finding of which is given at the end of the Preface.

The principal effect of parallax juſt found, 5m. 53ſ. I call the parallax in diſtance. With the altitude of the moon's centre, 9d. 38m. and the horiſontal parallax, 55m. take the moon's parallax in altitude, 54m. out of table, p. 26.

| | | |
|---|---|---|
| Sum of parallax in altitude, and parallax in diſt. 60′ | log. | 1.778 |
| Difference of parallax in alt. and parallax in diſt. 48′ | log. | 1.681 |
| App. diſt. of ſtar from the moon's centre 43° 36′ | cotan. | 10.021 |
| Conſtant logarithm | | 0.941 |
| Sum, abating 13 from the index | | 1.421 |

is logarithm of little correction of effect of parallax, 26ſ. to be added to 43d. 30m. 36ſ. the true diſtance of Antares from the moon's centre, found nearly above; whence the true and abſolute diſtance of Antares from the moon's centre is 43d. 31m. 2ſ.

Next, from the diſtance here found, 43d. 31m. 2ſ. and the moon's latitude computed from the tables, 4d. 55m. 17ſ. S. compute the difference of longitude between the ſtar and the moon, and thence the moon's true longitude, according to Chap. VI.

| | ° | ′ | ″ |
|---|---|---|---|
| Diſtance of Antares from the ſouth pole of the ecliptic, by table, page 4, is —— | 85 | 27 | 25 |
| Diſtance of the moon from ſouth pole of the ecliptic | 85 | 4 | 43 |
| Difference of polar diſtances —— | 0 | 22 | 42 |
| Half difference —— —— | 0 | 11 | 21 |
| Half true diſtance of moon from Antares found above | 21 | 45 | 31 |

| | |
|---|---|
| Half diſt. of moon from ſtar + ½ diff. 21° 56′ 52″ ſine | 9.5725944 |
| Half diſt. of moon from ſtar — ½ diff. 21 34 10 ſine | 9.5654093 |
| Polar diſt. of Antares 85° 27′ 25″ ar. compl. of ſine | 0.0013666 |
| Polar diſt. of the moon 85 4 43 ar. compl. of ſine | 0.0016041 |
| Sum —— —— | 19.1409744 |
| Half ſum, is ſine of 21° 50′ 10″ —— | 9.5704872 |

Doubled is 43 40 20 diff. of long. of moon and Antares.

| | S. | ° | ′ | ″ |
|---|---|---|---|---|
| Longitude of Antares in table, page 4, —— | 8 | 6 | 26 | 59 |
| Subſt. 50″ becauſe the year precedes 1763 by 1 year | | | | — 50 |
| Add correction for May 13, from table, page 5 | | | | + 53 |
| True longitude of Antares —— | 8 | 6 | 27 | 2 |
| To which add the difference of longitude of the moon and Antares found above (becauſe the moon is to the eaſt of the ſtar) =43° 40′ 20″= | 1 | 13 | 40 | 20 |

True

| | |
|---|---|
| True longitude of moon inferred from obſervations | 9 20 7 22 |
| Longitude of moon computed from tables to time aſſumed at Greenwich —— | 9 20 9 3 |
| Longitude of moon computed from tables, greater than that inferred from obſervations | 1 41 |
| Multiply by $29\frac{9}{10}$ the multiplier from table, p. 25, | $29\frac{9}{10}$ |
| | ° ' |
| Product ſhews how much the ſhip was eaſt of the aſſumed longitude, according to Chap. VII. —— | 0 50 E |
| But the longitude of the ſhip, according to its bearing and diſtance from the Lizard lights, was aſſumed weſt of Greenwich —— —— | 5 25 W |
| Therefore the true longitude of the ſhip by theſe obſervations is —— —— | 4 35 W |
| And the longitude of the Lizard, being 18' weſt of that of the ſhip, is —— —— | 4 53 W |

Which differs 0° 50' from the true longitude aſſigned to it in the tables.

In the foregoing obſervations, from whence the longitude of the ſhip has been computed, the ſea was almoſt perfectly calm, the motion thereof being very gentle and regular; ſo that it was rather an advantage to the obſervations in cauſing the ſtar to ſweep the moon's limb, than of any prejudice. I alſo determined the error of the adjuſtment of the quadrant very exactly by means of the moon, particularly by meaſuring her longeſt diameter ſeveral times with the reflected and direct images brought alternately to contrary ſides, with reſpect to each other; reading the numbers off the quadrant, in one caſe, in the uſual manner to the left hand of the beginning of the diviſions, and, in the other caſe, to the right hand of the ſame; and taking half the difference of the two meaſures of the moon's diameter thus found for the error of the adjuſtment; which method of finding the ſame I look upon to be as certain as any, eſpecially

cially near the time of the full moon, being more exact than by bringing the two images of the moon into one, and not leſs ſo than by the horiſon of the ſea. The night alſo was very fine, and there was a good twilight, which afforded me the opportunity of taking the altitudes of ſeveral ſtars pretty exactly; from the compariſon of all which together, as well as with the altitudes of the ſun taken in the evening before, and in the morning after the obſervations of the diſtance of the moon from Antares, I could be very certain of the time of the night at the ſhip.

### *Extract of the Journal of a Voyage from England to St, Helena in the Prince Henry Eaſt India Ship, corrected by Obſervations of the Diſtance of the Moon from the Sun and fixed Stars.*

TUESDAY, January 20, 1761, at noon, we took our departure from the Lizard Point, which bore then full north, diſtant by eſtimation 21 miles, allowing its longitude to be 5d. 14m. weſt from London, and its latitude 49d. 27m. north.

| Days of the month. | Latitude per obſervation at noon. | | Long. Weſt of London per comm. reckon. | | Long. weſt from obſer. of ☽, reduced to neareſt noon. | | Longit. by ☽ weſt of comm. reckoning. | | Number of obſervations taken of the diſtance of the moon's E. or W. limb from the ſun or ſtars to the eaſt or weſt. |
|---|---|---|---|---|---|---|---|---|---|
| | ° | ′ | ° | ′ | ° | ′ | ° | ′ | |
| Feb. 10 | 16 | 49 N | 27 | 33 | 30 | 22 | 2 | 49 | WL 8 from the ſun to the W |
| 11 | 14 | 3 | 26 | 47 | 29 | 22 | 2 | 35 | WL 10 from the ſun W |
| 15 | 5 | 10 | 22 | 44 | 23 | 39 | 0 | 55 | WL 2 from Regulus E |
| 19 | 1 | 42 | 22 | 44 | 23 | 35 | 0 | 51 | E L 5 from Pollux W |
| 28 | 9 | 6 S | 26 | 2 | 29 | 44 | 3 | 42 | E L 8 from the ſun E |
| Mar. 9 | 24 | 9 | 25 | 55 | 30 | 7 | 4 | 12 | WL 2 from Aldebaran E |
| 10 | 25 | 51 | 24 | 32 | 29 | 32 | 5 | 0 | WL 1 from Aldebaran E |
| 13 | 29 | 49 | 22 | 19 | 27 | 55 | 5 | 36 | WL 8 from the ſun W |
| | | | | | 27 | 44 | 5 | 25 | WL 1 from Regulus E |
| 15 | 30 | 8 | 22 | 8 | 26 | 52 | 4 | 44 | WL 4 from Regulus E |
| 17 | 30 | 39 | 18 | 58 | 24 | 50 | 5 | 52 | WL 3 from Pollux W |
| | | | | | 25 | 5 | 6 | 7 | WL 3 from the Virgin's Spike E |
| 18 | 31 | 1 | 18 | 47 | 24 | 0 | 5 | 13 | WL 4 from Pollux W |
| | | | | | 24 | 33 | 5 | 46 | WL 4 from the Virgin's Spike E |
| 19 | 31 | 37 | 17 | 7 | 21 | 41 | 4 | 34 | WL 3 from Pollux W |
| 20 | 32 | 4 | 15 | 27 | 20 | 19 | 4 | 52 | WL 3 from Pollux W |
| | | | | | 22 | 4 | 6 | 37 | WL 1 fr. Antares E taken in haſte |
| 25 | 31 | 23 | 5 | 57 | 12 | 4 | 6 | 7 | E L 3 from the Virgin's Spike W |
| 26 | 30 | 51 | 4 | 17 | 9 | 55 | 5 | 38 | E L 1 from the Virgin's Spike W |
| 29 | 30 | 32 | 1 | 13 | 6 | 49 | 5 | 36 | E L 3 from the ſun E |

April 6, 7 A. M. we came to an anchor in the harbour before James fort at St. Helena, when the longitude, by the common reckoning, was 1d. 28m. eaſt of London; but from my laſt obſervation of the diſtance of the moon from the ſun, March 29, was 4d. 16m. weſt of London. The longitude of St, Helena I find, by my obſervations of the eclipſes of Jupiter's ſatellites, to be 5d. 49m. weſt of Greenwich, or 5d. 44m. weſt of London. Therefore the error of the ſhip's common reckoning is 7d. 12m. eaſterly. But my account, deduced from the diſtances of the moon from the ſun, ſeven days before we made the iſland, differs only 1d. 28m. from the true longitude. Many reckonings kept on board the ſhip were no leſs than ten degrees erroneous.

## *Extract of the Journal of a Voyage from St. Helena to England, in the Warwick Eaſt India Ship, corrected by Obſervations of the Diſtance of the Moon from the Sun and fixed Stars.*

FRIDAY, Feb. 19, 1762, at 10 A. M. we got under ſail, and at noon took our departure from the iſland of St. Helena.

Feb. 25, at noon we made the iſland of Aſcenſion, and at 6¼ P. M. the Sugar-loaf point of Aſcenſion bore S. W. diſtance by eſtimation 12 miles. By the ſhip's reckoning we made 6d. 50m. difference of longitude from St. Helena to Aſcenſion, though the real difference, from aſtronomical obſervations, is 8d. 10m. ſo that we were ſet 1d. 20m. to the weſtward: we were alſo ſet 25m. in latitude to the northward in the ſame time.

Took a freſh departure from Aſcenſion, allowing it to lie, as by aſtronomical obſervations, in longitude 13d. 59m. weſt of the Royal Obſervatory at Greenwich, and in latitude 7d. 57m. S.

The next night, by a mean of three diſtances of the moon from Aldebaran, I found my longitude 22m. leſs than according to my departure, and diſtance run from that time; hence, by this obſervation, the longitude of Aſcenſion ſhould be 22m. leſs than aſſumed in my departure from thence, or 13d. 37m. weſt of Greenwich. But, as the longitude found by the obſervations of the moon, with Mayer's printed tables, is liable to an error, ſometimes of a whole a whole degree or more, this difference of 22m. is rather to be regarded as a proof of the exactneſs of this method of determining the longitude, than to be uſed to correct the aſſumed longitude, which may be ſuppoſed better eſtabliſhed by aſtronomical obſervations of a more delicate nature made on ſhore.

### *Extract of the Journal of the Remainder of the Voyage from our Departure taken from the Iſland of Aſcenſion to our Arrival at Plymouth.*

N. B. The latitudes and longitudes of the following table belong to the noon of the days to which they correſpond, the longitudes deduced from the obſervations of the moon having been reduced always to the noon immediately following them, by means of the ſhip's reckoning, except towards the end of the table, where the hour of the obſervations is ſet down, in which caſe the latitudes and longitudes are ſuch as correſpond to that hour. The bearings and diſtances of the land are alſo ſet down at the times of theſe latter obſervations, or as near to them as poſſible, in order to ſhew how near the longitudes deduced from the obſervations of the moon, agree both with one another, and alſo with the known longitudes of the Scilly Iſles, the Lizard, and Plymouth, which may be found very accurately from the tables of the latitudes and longitudes of places at the end of the tables.

| Days of the month. | Latitude obſerved. | | Longitude Weſt of Greenwich by common reckoning. | | Longitude Weſt, by obſervations of the moon. | | Longit. by ☽ Weſt of comm. reckoning. | | Number of obſervations taken of diſtance of the moon's E. or W. limb from the ſun or ſtars to the eaſt or weſt. |
|---|---|---|---|---|---|---|---|---|---|
| | ° | ′ | ° | ′ | ° | ′ | ° | ′ | |
| Mar. 9, Noon | 0 | 24 N | 18 | 14 W | 21 | 24 | 3 | 10 | WL 4 from Antares to E |
| | | | | | 21 | 44 | 3 | 30 | WL 3 fr. Virgin's Spike E |
| | | | | | 21 | 19 | 3 | 5 | WL 3 from Pollux W |
| 18, ditto | 5 | 19 | 22 | 53 | 27 | 19 | 4 | 26 | E L 3 from the ſun E |
| 28, ditto | 15 | 28 | 29 | 14 | 36 | 10 | 6 | 56 | WL 3 from Aldebaran E |
| 29, ditto | 17 | 3 | 29 | 45 | 37 | 1 | 7 | 16 | WL 2 from Pollux E |
| Apr. 8, Noon | 25 | 25 | 32 | 46 | 41 | 46 | 9 | 0 | WL 2 from Pollux W |
| 17, ditto | 32 | 50 | 28 | 41 | 38 | 28 | 9 | 47 | E L 2 from the ſun E |
| 28, ditto | 46 | 34 | 14 | 56 | 22 | 9 | 7 | 13 | WL 3 from Pollux E |
| | | | | | 22 | 17 | 7 | 21 | WL 1 from Regulus E |
| 29, ditto | 46 | 54 | 14 | 7 | 21 | 39 | 7 | 32 | WL 1 from Regulus E |
| May 3, Noon | 49 | 17 | 9 | 23 | 15 | 33 | 6 | 10 | WL 1 fr. Virgin's Spike E |
| | | | | | 16 | 59 | 7 | 36 | WL 1 from Pollux W |
| 6, ditto | 48 | 30 | 4 | 27 | 11 | 41 | 7 | 14 | WL 3 from Regulus W |
| | | | | | 11 | 45 | 7 | 18 | WL 2 from Antares E |
| 8, 10h. P. M. | 48 | 19 | 2 | 6 | 8 | 54 | 6 | 48 | E L 3 fr. Virgin's Spike W |
| 9, Midnight | 49 | 23 | 0 | 11 W | 7 | 16 | 7 | 5 | E L 3 fr. Virgin's Spike W |
| 10, 9h. A. M. | 49 | 43 | 0 | 11 E | 6 | 54 | - - - | | St. Agnes light-houſe bore N. 28 W. diſt. 5 leagues. |
| 11, 1h. A. M. | 49 | 52 | 0 | 22 | 6 | 5 | 6 | 27 | E L 4 fr. Virgin's Spike W<br>Scilly lights bore W. N. W. ½ W. diſtant 4 leagues. |
| 13, 2½h. A.M. | 49 | 50 | 1 | 53 | 4 | 35 | 6 | 28 | E L 5 from Antares E<br>Lizard lights bore N. 63 W. diſtant 13 miles. |
| 14, 9h. A. M. | 49 | 59 | 2 | 30 | 3 | 58 | | | Ediſtone light-houſe bore N. 22 E. diſt. 3 miles. |

At night, came to an anchor in Plymouth Sound, and the next morning went on ſhore.

*Remarks*

### *Remarks on the foregoing Extracts of the two Journals.*

I have laid before my readers the foregoing extracts of the journals of my two voyages, each containing a ſeries of longitudes of the ſhip, deduced from obſervations of the moon from time to time, compared with a reckoning kept in the common manner; both as proofs of the exactneſs of this method of finding the longitude at ſea, and alſo as examples which I hope to ſee imitated by navigators in future voyages. For tho' it is not very material for them to know their longitude very accurately, while they are in the middle of an ocean, and at a great diſtance from their intended port, but more particularly neceſſary when they are approaching it within the diſtance of 30 or 20, or fewer degrees: yet I ſhould rather recommend it to them, to determine their longitude by obſervation from time, ſuppoſe once in a week, ten days, or a fortnight; not only as it will render them more expert both in making the obſervations and calculations, againſt the time of their approach to their port, when they will have moſt occaſion to depend upon them; but alſo as they will by this means enrich their journals with materials, from whence, at leiſure, very uſeful inferences may be drawn, reſpecting currents, the variation of the compaſs, or other curious particulars.

The exactneſs with which the longitude may be found by theſe obſervations, may be ſhewn from the foregoing abridged journals by three different proofs. The firſt and principal one is from the near agreement of the longitude inferred by obſervations made within a few days or hours of making land, with the known longitude of ſuch land.

A ſecond proof may be drawn from the near agreement of the longitudes of the ſhip, inferred from obſervations made on a great many different days near to one another, when connected together by the help of the common reckoning.

A third argument, and, in my opinion, as cogent as any in proof of the certainty of this method of finding the longitude, may be deduced from the near agreement of the longitudes of the ſhip, deduced from obſervations of ſtars on different ſides of the moon, taken on the ſame night.

With reſpect to the firſt and principal proof, in my voyage out, I made the iſland of St. Helena within $1\frac{1}{3}$ degrees of its true ſituation, tho' by cloudineſs of weather, and the proximity of the moon to the ſun, I had not had an obſervation of the moon within eight days before: but in my voyage home, I found the Scilly Iſles by obſervations, which I took in the night a few hours before we made them, within 12 miles of their true ſituation, as I have ſhewn by the computation which I have diſtributed through the book, as an example of the rules. But if the ſecond correction of parallax be applied, as is done at the end of the Preface, (and as is alſo done with reſpect to the journal of my voyage from St. Helena home) the obſervations will agree ſtill nearer, or rather in a manner perfectly with the true ſituation of the Scilly iſles.

By obſervations taken the next night, being in ſight of the Scilly lights, I infer the longitude of St. Agnes lighthouſe to be 6d. 23m. weſt of the Royal Obſervatory at Greenwich, which is only 51m. leſs than its true longitude. Alſo by obſervations made May 8, at night, thirty hours before we made the Scilly Iſles, allowing for the ſhip's run in the mean time, the longitude of St. Agnes light-houſe comes out 6d. 49m. or only 25m. leſs than its true longitude. In like manner, by obſervations made May 13, in the morning, in ſight of the Lizard lights, the longitude of the Lizard point comes out 4d. 53m. weſt of Greenwich, or 50m. leſs than its true longitude. The only land which we ſaw in coming home was the Iſland of Aſcenſion, and I was not able to get one obſervation of the moon in the ſpace of the ſhort run from St. Helena thither, owing to clouds and the change of the moon happening in the intermediate time; but the next night after we had paſſed Aſcenſion, I had ſome very good obſervations, which gave me the longitude of the ſhip, agreeing within 22 minutes of a degree with my account, kept from the departure I took from Aſcenſion, whoſe longitude I aſſumed, as it has been determined from aſtronomical obſervations made on ſhore; or, allowing the ſhip's run backwards to the iſland of Aſcenſion, its longitude might be inferred from the ſaid obſervations, and would differ only 22 minutes of a degree from its true longitude. As therefore in none of theſe ſix inſtances, the longitude found from the obſervations of the moon differs a degree from the true longitudes of the places, except in the firſt inſtance, where the run of the ſhip is depended upon for eight days, and where the error of the reckoning, corrected by the laſt obſervations of the moon, gives the longitude of St. Helena only 1½ degrees different from its true ſituation, I think I have ſufficient foundation to ſuppoſe, that the longitude may be always found at ſea by this method, within the compaſs of a degree, or a very little more, which anſwers to about 40 geographical miles in the latitude of the Engliſh channel.

I obſerved, that a ſecond proof of the certainty of this method of finding the longitude, might be deduced from the near agreement of the longitudes of the ſhip, determined from obſervations made on a great many different days near to one another, when connected together by means of the ſhip's run. For this purpoſe I deſire the reader particularly to inſpect the ſeries of longitudes of the ſhip, deduced from obſervation, being no leſs than 12 in number, in the compaſs of 11 days, between March 9th and 20th, 1761, in my voyage out to St. Helena. Setting aſide any currents, as we were then in a pretty open ſea, and ſuppoſing the ſhip's run to be rightly allowed for from the log in the common account, during this time, the ſame difference ought to have been found between all the longitudes by account, and the correſponding longitudes deduced from the obſervations of the moon; or the ſame error of the common account ought to have reſulted from all the twelve obſervations. But as there is, as might be ſuppoſed, ſome difference between them, I take the mean of all the twelve errors of account, which is 5d. 20m. by which we were really more to the weſt than the common account made us; and, comparing each particular error of account with this quantity, the difference between them, in any of the twelve obſervations, ſcarce exceeds a degree; whence I think myſelf intitled to ſuppoſe, that the longitude was deduced truly from every one of the obſervations, within the compaſs of a degree, or not much more.

I have ſet down in the following table the error of the common account, and the difference between 5d. 20m. the mean quantity of it, and each particular error of account; which, except in the firſt and laſt obſervations, does not exceed three quarters of a degree.

The laſt obſervation, which differs moſt from the medium, was taken in ſome haſte, on account of the poſition of the ſails of the ſhip, which did not allow me an uninterrupted view of the ſtar; nevertheleſs, as I was tolerably ſatisfied with the obſervation at the time, I do not think proper to reject it.

| 1761 March | Error of account. | | Diff. from 5d. 20m. mean error | |
|---|---|---|---|---|
| | ° | ′ | ° | ′ |
| 9 | 4 | 12 | —1 | 8 |
| 10 | 5 | 0 | —0 | 20 |
| 13 | 5 | 36 | +0 | 16 |
| | 5 | 25 | +0 | 5 |
| 15 | 4 | 44 | —0 | 36 |
| 17 | 5 | 52 | +0 | 32 |
| | 6 | 7 | +0 | 47 |
| 18 | 5 | 13 | —0 | 7 |
| | 5 | 46 | +0 | 26 |
| 19 | 4 | 34 | —0 | 46 |
| 20 | 4 | 52 | —0 | 28 |
| | 6 | 37 | +1 | 17 |

Mean error of account, 5 20

The latter part of the extract of the journal of my voyage home to England affords a ſimilar proof of the conſiſtency of obſervations with each other in determining the longitude of the ſhip on ſeveral nights near to one another. Having ſufficiently ſatisfied myſelf of the certainty of theſe obſervations for finding the longitude, by the great number I made in my voyage out to St. Helena, in the month of March, 1761, I only thought it neceſſary in my voyage home to take ſo many from time to time, at the diſtance of a week or ten days from one another, as was ſufficient to correct the reckoning, without leaving room for any conſiderable error to creep into it. But towards the end of my voyage, at the latter end of April, and during the firſt part of the month of May, till our arrival at Plymouth, I omitted no opportunity of making obſervations that I could gain; and from the 28th of April to the 13th of May, that is to ſay, in the compaſs of 15 days, I was ſo fortunate as to obtain no leſs than 11 different ſets of obſervations, all which ſhew the error of the ſhip's reckoning the ſame, within the compaſs of 1d. 26m. for the greateſt error of the ſhip's account from one of the obſervations May 3, is 7d. 36m. and the leaſt error of account is from the other obſervation on the ſame day, 6d. 10m. But to ſet this point in a fuller light, I have, in the following table, made a like compariſon of theſe obſervations with the common reckoning, as I have done above with reſpect to the obſervations I made in my voyage to St. Helena between March 9th and 20, 1761.

| 1762 April | | Error of account. | | Difference from mean error. | |
|---|---|---|---|---|---|
| | | ° | ′ | | ′ |
| | 28 | 7 | 13 | + | 12 |
| | | 7 | 21 | + | 20 |
| | 29 | 7 | 32 | + | 31 |
| May | 3 | 6 | 10 | — | 51 |
| | | 7 | 36 | + | 35 |
| | 6 | 7 | 14 | + | 13 |
| | | 7 | 18 | + | 17 |
| | 8 | 6 | 48 | — | 13 |
| | 9 | 7 | 5 | + | 4 |
| | 11 | 6 | 27 | — | 34 |
| | 13 | 6 | 28 | — | 33 |

Mean error of account, 7 1

In this compariſon the greateſt difference between the mean error of account and the ſeveral particular errors of account, is under one degree; and therefore it ſeems probable, that the greateſt error made in determining the longitude from any of theſe eleven obſervations, does not much exceed this quantity: eſpecially, ſince the greateſt difference between the two errors of account which differ moſt widely from each other, is only one degree, twenty-ſix minutes.

On this occaſion I muſt confeſs, that notwithſtanding the many and frequent proofs I have had of the certaintyand exactneſs of theſe kind of obſervations, and tho' I am ſenſible I ſpared no pains in making thoſe I am treating of with all the care in my power; yet I am not a little ſurpriſed myſelf at finding ſo near an agreement of ſo many with one another, particularly becauſe ſeveral of them are ſingle ones, and the time, in ſome of them, was determined from altitudes of the ſtars in the night. But I would not be underſtood by this to mean to arrogate any peculiar merit or ſkill to myſelf in making theſe obſervations, which others may not equally attain with the ſame care and experience; ſince I am ſatisfied, from the near agreement of many obſervations, taken by the officers of the Warwick, with my own, taken at the ſame inſtant, that mariners properly inſtructed in making the obſervations, as I flatter myſelf they will find themſelves to be by means of my ſecond Chapter, and moderately exerciſed in the practice of them, which is their own part, will be able to determine their longitude, by only adhering ſtrictly to my rules, within the limits I have already mentioned, namely, about a degree.

The third proof of the certainty of the obſervations of the moon for finding the longitude at ſea, which may be deduced from the foregoing extracts of my journals, is what reſults from the near agreement of the double longitudes of the ſhip deduced from diſtances of the moon from ſtars on different ſides of her, taken on the ſame night; for all the moſt probable kinds of error, that can be ſuppoſed in the obſervations, whether ariſing from a faulty diviſion of the limb of the inſtrument, a refraction in the ſpeculums or dark glaſſes, a wrong allowance for the correction of the adjuſtment, or a ſuppoſed bad habit of eſtimating the contact of a ſtar with the moon's limb too open, affecting the computation of the longitude from ſtars on different ſides of the moon different ways; their ill effect, if any, muſt be ſenſible in the reſult. But ſince in all the inſtances of the double longitudes thus determined, contained in the journal, the difference is very ſmall, and ſuch as fully juſtifies what I have already advanced, with reſpect to the degree of exactneſs with which the longitude may be determined at ſea, it is evident, that by good inſtruments and careful obſervations, theſe errors may be ſo far reduced, as to be of very little conſequence.

I have one more remark to add, reſpecting the journal of my voyage from St. Helena to England, which I flatter myſelf will not be thought foreign to the purpoſe; that April 20th and 21ſt, 1762, while we were croſſing the parallels of latitude of the weſtern iſlands, we ought, by the common reckonings of the ſhip, to have been ſailing thro' the midſt of them, which could not have happened without our, at leaſt, ſeeing ſome of them: but this is eaſily reconciled from the obſervations of the moon, by which it appears, that the ſhip was at that time nine or ten degrees farther to the weſt than the common reckonings made it; ſo that if through diſtreſs of weather, or other accidents, we had wanted to make any of thoſe iſlands, we could not have done it by the common reckonings; but it cannot be doubted, after the proofs that have been already given, that we might have readily and certainly found them by means of the longitude of the ſhip, corrected by the obſervations of the moon, if we had wanted it.

## *An Account of the Principles and Authority upon which the following Tables depend.*

THE depreſſion of the horiſon of the ſea, contained in the firſt table, page I. I have made leſs by one tenth part, than it is ſtated in the common tables, deduced from the known dimenſions of the earth; having found, both from theory and experiments, this correction to be neceſſary on account of the refraction of the rays of light in paſſing thro' the atmoſphere.

The next table, which is new, ſhewing the depreſſion of the water's edge of land at a given diſtance, I have computed from the known dimenſions of the earth, paying alſo a regard to the effect of refraction. I apprehend it may be very uſeful when the horiſon is land-locked on the ſide it may be wanted to obſerve; ſince, if the diſtance of the land adjoining to the water can be eſtimated nearly, the quantity of depreſſion taken out of this table may be applied, inſtead of the depreſſion of the horiſon in the former table.

The next table is computed from a rule formerly communicated to me by the late Dr. Bradley, and deduced by him from his obſervations, according to the principles contained in a paper of the late Mr. Simpſon's, in his Mathematical Diſſertations. The rule is, that the refraction at any altitude is to 57ſ. the mean refraction at the altitude of 45d. as the tangent of the apparent zenith diſtance, leſſened by three times the refraction, taken nearly out of any common table of refraction : is to the radius. This is adapted to an altitude of Fahrenheit's thermometer of 50d. and to an altitude of the barometer of $29\frac{6}{10}$ inches : and in this ſtate of the air has been found by Dr. Bradley to anſwer very nearly to obſervation quite down to the horiſon. In other ſtates of the air, he found the refraction to be to the quantity contained in this table, in a ratio compounded of the direct ratio of the altitude of the barometer to $29\frac{6}{10}$ inches, and in a reciprocal ratio of the altitude of the thermometer, increaſed by 350 to the number 400. As ſailors have occaſion to correct their altitudes only to ſingle minutes, I thought it would be more convenient for their uſe to ſet down the degrees and minutes of altitude, which anſwer to the even minutes of refraction, than to give the table in the common manner. Refraction cauſing the heavenly bodies to appear higher than they really are, all altitudes obſerved ought to be diminiſhed by the numbers contained in the table; but particularly the altitudes of the ſun, taken for computing his azimuth, in order to find the variation of the compaſs from obſervation, being generally very near the horiſon, ought to be ſo corrected. From the effect of refraction alſo, the ſun appearing to be in the horiſon, when he is really half a degree below it; though he is really in the horiſon, when his center appears at the altitude of 29 minutes above it; therefore the proper time for taking an amplitude is not when the ſun appears in the horiſon, but when his centre appears 29 minutes high, or his lower limb 15, or his upper limb 43 minutes high: but the apparent altitude of the ſun above the viſible horiſon of the ſea ſhould be greater than theſe numbers by the quantity of the dip of the horiſon, taken out of the firſt table.

The catalogue of right aſcenſions and declinations of ſtars, page II. and III. is ſelected from the Abbe de la Caille's obſervations, and is deſigned both for finding the time and the latitude, by altitudes taken in the night.

The next table, page III. and IV. ſerves to turn degrees and minutes of the equator into time, and the contrary, at the rate of 15d. to 1h. and 15m. to 1m. of time, &c. Thus the longitude from Greenwich by account is frequently turned into time, and *vice verſâ*, the apparent time in Rule 3d of the Appendix, is turned into degrees and minutes of the equator.

The table of limits, which the difference or ſum of the moon and ſtars latitudes ſhould not exceed, ought to be carefully attended to in chuſing out a proper ſtar for obſerving the diſtance of the moon from, *Vide* page 12, Chap. II. The principal reaſon for this is, that the moon's latitude, uſed in the computations of the 6th Chapter, may ſometimes err three minutes: for the latitude, as found from the tables, is ſometimes liable to an error of 2 minutes; and, if the ſhip's account be out 5d. this will make an error of 20 minutes in the aſſumed time at Greenwich, and may therefore ſometimes occaſion an error of a minute more in computing the moon's latitude. But if the ſtar be choſen agreeable to the table of limits, an error even of three minutes in the moon's latitude will not occaſion above 15ſ. error in the reſult of the computations of Chap. VI. in finding the moon's true longitude from the obſervations.

The catalogue of the longitudes and latitudes of twelve zodiacal ſtars, page IV. proper for obſerving the diſtance of the moon from, in order to determine the longitude, is taken from the beſt modern obſervations.

In the table, page V. calculated for every tenth day in the year, I have included the ſemidiameter and hourly motion of the ſun, and have thrown together into one ſum the increaſe of the ſtar's longitude, owing to the preceſſion of the equinoxes from the beginning of the year, and the aberration in longitude. But as this ſum was ſometimes negative, I have in thoſe caſes added the greateſt negative quantity to every number in its reſpective table, and have ſubſtracted the ſame from the epochs of longitude at the bottom of page IV. ſo that the corrections of page V. are always additive.

The mean motions of the ſun and moon are ſet down agreeable to tables of them, which I received as a preſent from Mr. Gael Morris, being ſuch as he had conſtructed himſelf from the compariſon of a great number of the late Dr. Bradley's obſervations. The equation of time is alſo taken from the ſame tables.

The equation of the ſun's centre, and the tables of the equations of the moon, latitude, and parallax, are taken from Mr. Mayer's tables, as printed in the ſecond volume of the Gottingen Acts, excepting two ſlight alterations, which I have made in order to ſave a little trouble in the calculations, without hurting their exactneſs. One of the alterations I have made is by leaving out the annual equation of the mean anomaly and node, and making the firſt equation of the moon ſerve inſtead of it. This alteration, I own, may ſometimes occaſion a difference of 14ſ. in the computation of the moon's longitude; but then I find, that in Mr. Mayer's manuſcript tables, which I have ſeen, the value of the annual equation of the mean anomaly is increaſed ſo as to approach towards the value of double the firſt equation. The other alteration which I have made, is in ſubſtituting a more eaſy manner of taking out the argument of latitude the ſecond, inſtead of Mr. Mayer's, which can never make a difference of more than 8ſ. from the ſame taken out with

Mr. Mayer's argument. The alteration I have made in taking out equation the firſt of the moon for the annual equation of the node, may alſo occaſion a difference in the moon's latitude of 5ſ. But both theſe differences are of no conſequence, ſince the moon's latitude computed by theſe tables is ſometimes liable to err three minutes; and this being of no prejudice, if the ſtar be properly choſen, a ſmaller difference of a few ſeconds cannot be worth regarding.

I have added, page XXIV. and XXV. three tables of the hourly motion of the moon, conſtructed by myſelf, which were much wanted, being not to be found in any books of tables that I have ſeen.

I have added a table of multipliers, page XXV. in order to ſave a little trouble in the computations: they are the quotients of 15d. or 900 minutes, divided by the hourly motion of the moon, or the difference of the hourly motions of the ſun and moon, which are the two firſt terms of the proportion preſcribed at the beginning of the 7th Chapter.

The table of the moon's parallax in altitude, page XXVI. is uſeful in computing the moon's apparent altitude, if it had not been obſerved, *vide* page 57 and 60; alſo in Article IV. in the reſolution of the problem in the Appendix, where the altitude of the moon is firſt corrected by parallax, in order to compute the time from: alſo in finding the latitude from the moon's meridian altitude: and alſo in computing the ſecond and ſmall correction of parallax, which was omitted in Chap. V. but is delivered at the end of the Preface.

The tables of the declination and right aſcenſion of the degrees of the ecliptic, page XXVI. XXVII. and XXVIII.

are uſeful for finding the moon's declination and right aſcenſion, by the two rules in the appendix, page 54, from her longitude and latitude given: alſo for finding the ſun's right aſcenſion from his longitude, whether in computing the time from the altitude of a ſtar or the moon, or in computing the apparent altitude of the moon and ſtar from the apparent time given.

I have added the laſt table, containing the longitudes and latitudes of places that have been determined from aſtronomical obſervations, as a proper and neceſſary part of this work, and I hope it will appear an acceptable preſent to the public. As the method of finding the longitude by obſervations of the moon, or indeed any method of finding the longitude, can only agree with the true longitudes of places; and as thoſe determined from aſtronomical obſervations are the only ones that are abſolutely certain, ſo I would be underſtood to ſubmit the method of finding the longitude propoſed in this book to a trial only by a compariſon with the longitudes of places contained in the table; I mean, with reſpect to the degree of exactneſs which I have inferred from my own experience to be attainable by this method. But if the navigator, on making of land, ſhould find his account, deduced from obſervations of the moon, to differ much above a degree from the longitudes of places which are not contained in the table, but taken from other authorities, I hope he will be ſo candid as to ſuppoſe, that this greater ſeeming diſagreement of his obſervations with the land made, rather ariſes from ſome error in the longitude of the land, aſſumed from too inſufficient authority, than to any defect in a method which may ſeem from ſo many experiments to be ſufficiently proved.

In order to render the foregoing table of longitudes and latitudes of places as compleat as poſſible, I have conſulted all the beſt authorities I could find. In particular, I have borrowed all the places that are contained in the French Almanack, called the *Connoiſſance des temps*, for 1760, and in the explanation of the annual calculations of the ſame almanack, publiſhed in 1762, with very little alteration, only reducing them to the meridian of the Royal Obſervatory at Greenwich. For the longitudes of other places which I have here added, and which reſult from obſervations made in the latter end of the laſt, or the beginning of the preſent century, I refer the reader to the books or memoirs in which they are deſcribed, and which are to be ſuppoſed well known to geographers; but I ſhall give a brief account of the authorities upon which I give the longitudes of ſeveral places, deduced from more modern obſervations. Many of theſe are determined from the obſervations of the late tranſit of the planet Venus over the ſun.

Thus I have deduced the longitude of Leaſkard in Cornwall from the obſervation made there by the Reverend Mr. Haydon; that of the univerſity of Cambridge from a mean of the obſervations made there by ſeveral ingenious gentlemen, tho' their modeſty has prevented them from communicating them to the public; that of Exeter in Devonſhire, from the obſervation of Mr. Chapple; that of Stalbridge in Devonſhire, from the obſervation of the Rev. Mr. Bolton; and that of Wakefield in Yorkſhire, from the obſervation of Mr. George Gargrave.

The obſervation of the Rev. Mr. Haydon is particularly valuable, both as it was made with good inſtruments, and as it ſerves, with the help of the maps of the county of

Cornwall, to determine very nearly the longitude of Plymouth, Falmouth, the Lizard Point, the Land's-end, and the Scilly Iſles; all which places are generally either the laſt that ſhips ſee in going out of the channel outward bound, or which they make firſt upon coming into the channel homeward bound.

The other places, whoſe longitudes are deduced from the late tranſit of Venus, are Leyden in Holland, from the obſervation of Mr. Profeſſor Lulofs, (and hence alſo that of the Hague and Rotterdam, by their known poſition to Leyden); alſo Drontheim in Norway, from the obſervation of Mr. George N. Holm; Carelſcroon and Landſcroon in Sweden, from obſervations made there, but I am not acquainted with the names of the obſervers; Tobolſki in Siberia, from the obſervation of M. L' Abbè de Chappe; and St. John's in Newfoundland, from the obſervation of Mr. Winthrop, who ſailed thither with proper inſtruments from New England for that purpoſe. The longitude of Fort St. George in the Eaſt Indies reſults from the obſervation of the tranſit of Venus made there by the Rev. Mr. Hirſt; that of Calcutta in Bengal, from the obſervation of Mr. Magee; and that of Iſlamabad from the obſervations of Meſſ. Knott and Plaiſted. For theſe four laſt obſervations we are indebted to the Directors of the Eaſt-India Company, who ſent out general inſtructions to all their ſettlements, particularly recommending this obſervation to ſuch as ſhould be capable of it.

The longitudes of the following places I have determined from obſervations of the eclipſes of Jupiter's firſt ſatellite, compared with correſponding ones made at Greenwich, or elſewhere; or, if not correſponding, yet happening within a few periods, and compared with the help of the tables. The longitude of the iſland of St. Helena I deduce from my own obſervations made there in the year 1761; the longitude of the Cape of Good Hope, from the obſervations made there by Mr. Charles Maſon and Mr. Jeremiah Dixon in the ſame year. The longitude of the iſland of Rodrigues in the Ethiopic obſervation, from the obſervations of M. Pingré; and Caſan in Ruſſia, from two emerſions, one of the firſt, and the other of the ſecond ſatellite, obſerved there by M. L' Abbè de Chappe, in the year 1761. The longitude of Cape Francois I deduce from an emerſion of the firſt ſatellite of Jupiter, obſerved there in the year 1745, by Don George Juan, one of the two Spaniſh mathematicians who went to Peru in conjunction with the French academicians, to meaſure the degrees of the meridian, which I compared with a computation which I have made of the ſame, from Mr. Wargentin's tables, publiſhed by M. De la Lande, not having poſſeſſion of any obſervations made in England or elſewhere at that time. The longitudes of Stockholm, Hernoſand, and Cajaneburg, all in Sweden, are taken from the authority of Mr. Wargentin. *Vide* papers 39th and 44th, Vol. LII. Part I. of the *Philoſophical Tranſactions* for the year 1761. The ſame volume alſo contains moſt of the obſervations of the tranſit of Venus which have been made uſe of in determining the longitudes of the places already mentioned, which are inſerted in the table.

The longitude of Cape Clear in Ireland was determined from eclipſes of Jupiter's ſatellites, by the obſervers appointed by Mr. Whiſton to ſurvey the coaſts of the channel. The longitude of the city of York was determined by Mr. Richard Norwood, from the ſame menſurations by which he inferred the length of the degrees of the meridian between London and York.

I am obliged to Mr. James Short, F.R.S. for the latitude and longitude of Edinburgh, the latter reſulting from the obſervations of the eclipſes of Jupiter's ſatellites, made there formerly by himſelf: as alſo for the longitude of Port Royal in Jamaica, computed by himſelf from the obſervation of the external contact of Mercury with the ſun's limb in the year 1753, taken by Mr. Macfarlane. The longitudes and latitudes of Louiſbourg, Cape Sable, and the Straits of Fronſac, between Nova Scotia and the iſland of Cape Breton, are taken from M. Chabert's accurate obſervations. The ſituation of Achem, the north-weſt point of the iſland of Sumatra, and that of the iſland of Pulo Timon in the Gulf of Siam, I have taken from the authority of M. d' Aprés de Mannevillette, in his *Neptune Orientale*; as alſo the longitude of Manilla in the Philippine iſlands; the two firſt being accurately ſettled by him from their latitudes and bearings from Malacca, and the latter ſufficiently determined from ſeveral ſhort runs of ſhips to and from the iſland of Pulo Condor, which is ſettled from aſtronomical obſervations. The longitude of Callao in the South Seas depends on that of the city of Lima, of which it is the port, and which is known from aſtronomical obſervations.

The poſitions of Cape Lorenzo and Guaquil, likewiſe in the South Seas, are ſettled relatively to the city of Quito in Peru, by the trigonometrical menſurations of the gentlemen who meaſured the degrees of the meridian in Peru; therefore I have ſet down their longitudes agreeable to that of Quito contained in the tables, and the difference between the longitudes of thoſe places and Quito, ſuppoſed in Don George Juan's accurate chart of the weſtern coaſt of South America: the longitude of Quito contained in the tables, and which reſults from eclipſes of Jupiter's firſt ſatellite, being much more certain than its longitude aſſumed in the chart from eclipſes of the moon.

Laſtly, the longitude of Panama in the South Seas is pretty accurately determined with reſpect to Porto Bello, lying on the other ſide of the Iſthmus, from which it was found to lie only 31 minutes of a degree to the weſt, by the eſtimation of the direction, and length of the way from the latter place to the former, made by the Spaniſh mathematicians who went to Peru to meaſure the degrees of the meridian.

THE END.

# A
# SETT
# OF
# Correct Aſtronomical TABLES.

# TABLES for finding the Longitude by Sea and Land.

## A Table of the Depreſſion or Dip of the Horiſon of the Sea for different Elevations of the Eye above the Surface.

| Elevation of the Eye above the Sea in Feet. | Depreſſion of the Horiſon of the Sea in Minutes. |
|---|---|
| 1 | 1 |
| 4 | 2 |
| 10 | 3 |
| 17 | 4 |
| 27 | 5 |
| 39 | 6 |
| 53 | 7 |
| 69 | 8 |

## A Table ſhewing how many Minutes the Water's Edge at any Land at a given Diſtance is depreſſed below the true Level for different Elevations of the Eye above the Surface of the Water.

| Diſtance of the Land in Sea Miles. | Elevation of the Eye above the ſurface of the water in feet | | | |
|---|---|---|---|---|
| | 10 F. | 17 F. | 27 F. | 39 F. |
| | Depreſſion of the Land at the Water's Edge below the true Level in Minutes. | | | |
| ¼ | 22 | 38 | 61 | 88 |
| ½ | 11 | 19 | 30 | 44 |
| ¾ | 8 | 13 | 20 | 29 |
| 1 | 6 | 10 | 15 | 22 |
| 1¼ | 5 | 8 | 12 | 18 |
| 1½ | 4 | 7 | 11 | 15 |
| 2 | 3 | 5 | 8 | 12 |
| 2½ | 3 | 5 | 7 | 10 |
| 3 | 3 | 4 | 6 | 8 |
| 3½ | 3 | 4 | 6 | 7 |
| 4 | 3 | 4 | 5 | 7 |
| 5 | 3 | 4 | 5 | 6 |
| 6 | 3 | 4 | 5 | 6 |

## A Table of the Refraction of the Heavenly Bodies at different Altitudes.

| Apparent Altitude. | Refraction in Minutes. |
|---|---|
| ° ′ | ′ |
| 0. 0 | 33 |
| 0. 4 | 32 |
| 0. 12 | 31 |
| 0. 19 | 30 |
| 0. 27 | 29 |
| 0. 33 | 28 |
| 0. 40 | 27 |
| 0. 48 | 26 |
| 0. 56 | 25 |
| 1. 4 | 24 |
| 1. 13 | 23 |
| 1. 22 | 22 |
| 1. 32 | 21 |
| 1. 43 | 20 |
| 1. 55 | 19 |
| 2. 7 | 18 |
| 2. 21 | 17 |
| 2. 36 | 16 |
| 2. 53 | 15 |
| 3. 11 | 14 |
| 3. 32 | 13 |
| 3. 56 | 12 |
| 4. 24 | 11 |
| 4. 56 | 10 |
| 5. 36 | 9 |
| 6. 22 | 8 |
| 7. 23 | 7 |
| 8. 42 | 6 |
| 10. 30 | 5 |
| 13. 10 | 4 |
| 17. 28 | 3 |
| 25. 20 | 2 |
| 43. 34 | 1 |
| 51. 40 | 0¾ |
| 62. 20 | 0½ |
| 75. 13 | 0¼ |
| 90. 0 | 0 |

## A Catalogue of the Right Aſcenſions and Declinations of the principal fixed Stars of the 1ſt and 2d Magnitude, adapted to the Beginning of the Year 1765, with their Variations in ten Years.

| Names of the Stars. | Character | Magnitude. | Right Aſcenſion. | R. Aſc. increaſing in 10years | Declination. | Dec. inc. or diminiſhes in 10years. |
|---|---|---|---|---|---|---|
| | | | ° ′ | ′ ″ | ° ′ | ′ ″ |
| Extremity of the Wing of Pegaſus, *Algenib* | γ | 2 | 0.17 | 7. 42 | 13. 53 *N.* | +3. 20 |
| In the Head of the Phœnix | α | 2 | 3.39 | 7. 30 | 43. 35 *S.* | −3. 20 |
| The bright Star in the Tail of the Whale | β | 2 | 7.57 | 7. 32 | 19. 17 *S.* | −3, 18 |
| In the Girdle of Andromeda | β | 2 | 14. 9 | 8. 14 | 34. 22 *N.* | +3. 14 |
| The Spring of the River Eridanus, *Achernar* | α | 1 | 22.14 | 5. 37 | 58. 26 *S.* | −3. 5 |
| In the Jaw of the Whale | α | 2 | 42.30 | 7. 49 | 3. 9 *N.* | +2. 28 |
| In the Head of Meduſa, *Algol* | β | 2 | 43. 5 | 9. 36 | 40. 2 *N.* | +2. 26 |
| The bright Star of Perſeus | α | 2 | 46.55 | 10. 29 | 49. 0 *N.* | +2. 17 |
| The South Eye of the Bull, *Aldebaran* | α | 1 | 65.37 | 8. 34 | 16. 1 *N.* | +1. 23 |
| The bright Star in the left Shoulder of Auriga, *Capella* | α | 1 | 74.50 | 11. 0 | 45. 44 *N.* | +0. 53 |
| The bright Foot of Orion, *Rigel* | β | 1 | 75 42 | 7. 12 | 8. 29 *S.* | −0. 50 |
| The North Horn of the Bull | β | 2 | 77.42 | 9. 27 | 28. 23 *N.* | +0. 43 |
| The Weſtern Shoulder of Orion | γ | 2 | 78. 8 | 8. 3 | 6. 7 *N.* | +0. 42 |
| Bright Star in the Dove | α | 2 | 82.47 | 5. 30 | 34. 13 *S.* | −0. 25 |
| The Eaſtern Shoulder of Orion | α | 1 | 85.37 | 8. 7 | 7. 21 *N.* | +0. 16 |
| The bright Star in the Poop of the Ship Argo, *Canobus* | α | 1 | 94.41 | 3, 21 | 52. 34 *S.* | +0. 16 |
| The bright Star in the Dog's Mouth Sirius | α | 1 | 98.42 | 6. 43 | 16. 24 *S.* | +0. 30 |
| In the Head of the Northern Twin Caſtor | α | 1 | 109.53 | 9. 41 | 32. 23 *N.* | −1. 7 |
| The little Dog Procyon | α | 1 | 111.45 | 8. 0 | 5. 49 *N.* | −1. 13 |
| In the Head of the Southern Twin Pollux | β | 1 | 112.44 | 9. 23 | 28. 35 *N.* | −1. 17 |
| Bright Star in the Oars of the Ship Argo | β | 1 | 137.38 | 1. 52 | 68. 45 *S.* | +2. 28 |
| The Heart of the female Hydra | α | 2 | 139. 1 | 7. 24 | 7. 39 *S.* | +2. 31 |
| The Lyon's Heart, *Regulus* | α | 1 | 148.57 | 8. 6 | 13. 6 *N.* | −2. 51 |
| The Northernmoſt Star in the Square of the great Bear | α | 2 | 162.15 | 9. 44 | 63. 1 *N.* | −3. 10 |
| The Lyon's Tail | β | 2 | 174.16 | 7. 47 | 15. 53 *N.* | −3. 19 |
| The ſouthernm. Star of the Croſiers, or the ft of the Croſs | α | 1 | 183.26 | 8. 3 | 61. 48 *S.* | +3. 20 |
| The Virgin's Spike | α | 1 | 198.13 | 7. 52 | 9. 55 *S.* | +3. 10 |
| The laſt Star in the Tail of the great Bear | η | 2 | 204.34 | 6. 1 | 50. 30 *N.* | −3. 2 |
| The Weſternmoſt Foot of the Centaur | β | 2 | 206.52 | 10. 13 | 59. 13 *S.* | +2. 59 |
| The bright Star in Bootes, *Arcturus* | α | 1 | 211.14 | 7. 3 | 20. 25 *N.* | −2. 52 |
| The bright Star in the Eaſtern Foot of the Centaur | α | 1 | 215.59 | 11. 1 | 59. 51 *S.* | +2. 42 |
| The Southern Scale of Libra | α | 2 | 219.29 | 8. 16 | 15, 3 *S.* | +2. 35 |
| The Northern Scale of Libra | β | 2 | 226. 6 | 8. 3 | 8. 30 *S.* | +2. 20 |
| The bright Star of the Crown | α | 2 | 231.11 | 6. 20 | 27. 31 *N.* | −2. 6 |
| The Northernmoſt Star in the Scorpion's Forehead | β | 2 | 237.57 | 8. 40 | 19. 8 *S.* | +1. 47 |

## A Continuation of the Table of the Right Aſcenſions and Declinations of the principal fixed Stars.

| Names of the Stars. | Character. | Magnitude. | Right Aſcenſion. | R. Aſc. increaſing in 10 years | Declination. | Dec. inc. or diminiſhes in 10 years. |
|---|---|---|---|---|---|---|
| | | | ° ′ | ′ ″ | ° ′ | ′ ″ |
| The Scorpion's Heart, *Antares* | α | 1 | 243. 45 | 9. 8 | 25. 53 S. | + 1. 29 |
| In the Eaſtern Knee of Ophiucus | η | 2 | 254. 14 | 8. 36 | 15. 25 S. | + 0. 55 |
| The Head of Ophiucus | α | 2 | 261. 0 | 6. 57 | 12. 45 N. | − 0. 32 |
| The bright Star of the Harp, *Lyra* | α | 1 | 277. 15 | 5. 3 | 38. 35 N. | + 0. 25 |
| The bright Star of the Eagle, *Atair* | α | 2 | 294. 50 | 7. 15 | 8. 16 N. | + 1. 23 |
| The Eye of the Peacock | α | 2 | 301. 44 | 12. 13 | 57. 28 S. | − 1. 44 |
| The Tail of the Swan | α | 2 | 308. 21 | 5. 7 | 44. 27 N. | + 2. 4 |
| The Weſternmoſt Wing of the Crane | α | 2 | 328. 20 | 9. 56 | 48. 5 S. | − 2. 50 |
| In the Mouth of the Southern Fiſh, *Fomalhaut* | α | 1 | 341. 9 | 8. 21 | 30. 52 S. | − 3. 9 |
| In the Shoulder of Pegaſus | β | 2 | 343. 6 | 7. 12 | 26. 49 N. | + 3. 11 |
| In the Wing of Pegaſus, *Markab* | α | 1 | 343. 16 | 7. 27 | 13. 57 N. | + 3. 12 |
| The Head of Andromeda | α | 2 | 359. 4 | 7. 40 | 27. 47 N. | + 3. 20 |

## A Table to turn Degrees and Minutes of the Diurnal Motion into Hours, Minutes, and Seconds of Time.

| D. M. | M. S. | D. M. | H.M. M. S. | D. M. | H.M. M. S. | D. M. | H.M. M. S. | D. | H.M. | D. | H.M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 16 | 1. 4 | 31 | 2. 4 | 46 | 3. 4 | 61 | 4. 4 | 76 | 5. 4 |
| 2 | 8 | 17 | 1. 8 | 32 | 2. 8 | 47 | 3. 8 | 62 | 4. 8 | 77 | 5. 8 |
| 3 | 12 | 18 | 1. 12 | 33 | 2. 12 | 48 | 3. 12 | 63 | 4. 12 | 78 | 5. 12 |
| 4 | 16 | 19 | 1. 16 | 34 | 2. 16 | 49 | 3. 16 | 64 | 4. 16 | 79 | 5. 16 |
| 5 | 20 | 20 | 1. 20 | 35 | 2. 20 | 50 | 3. 20 | 65 | 4. 20 | 80 | 5. 20 |
| 6 | 24 | 21 | 1. 24 | 36 | 2. 24 | 51 | 3. 24 | 66 | 4. 24 | 81 | 5. 24 |
| 7 | 28 | 22 | 1. 28 | 37 | 2. 28 | 52 | 3. 28 | 67 | 4. 28 | 82 | 5. 28 |
| 8 | 32 | 23 | 1. 32 | 38 | 2. 32 | 53 | 3. 32 | 68 | 4. 32 | 83 | 5. 32 |
| 9 | 36 | 24 | 1. 36 | 39 | 2. 36 | 54 | 3. 36 | 69 | 4. 36 | 84 | 5. 36 |
| 10 | 40 | 25 | 1. 40 | 40 | 2. 40 | 55 | 3. 40 | 70 | 4. 40 | 85 | 5. 40 |
| 11 | 44 | 26 | 1. 44 | 41 | 2. 44 | 56 | 3. 44 | 71 | 4. 44 | 86 | 5. 44 |
| 12 | 48 | 27 | 1. 48 | 42 | 2. 48 | 57 | 3. 48 | 72 | 4. 48 | 87 | 5. 48 |
| 13 | 52 | 28 | 1. 52 | 43 | 2. 52 | 58 | 3. 52 | 73 | 4. 52 | 88 | 5. 52 |
| 14 | 56 | 29 | 1. 56 | 44 | 2. 56 | 59 | 3. 56 | 74 | 4. 56 | 89 | 5. 56 |
| 15 | 60 | 30 | 2. 0 | 45 | 3. 0 | 60 | 4. 0 | 75 | 5. 0 | 90 | 6. 0 |

## A Contniuation of the Table to turn Degrees into Time.

| D. | H.M. | D. | H.M. | D. | H.M. | D. | H.M. |
|---|---|---|---|---|---|---|---|
| 95 | 6.20 | 170 | 11.20 | 245 | 16.20 | 320 | 21.20 |
| 100 | 6.40 | 175 | 11.40 | 250 | 16.40 | 325 | 21.40 |
| 105 | 7. 0 | 180 | 12. 0 | 255 | 17. 0 | 330 | 22. 0 |
| 110 | 7.20 | 185 | 12.20 | 260 | 17.20 | 335 | 22.20 |
| 115 | 7.40 | 190 | 12.40 | 265 | 17.40 | 340 | 22.40 |
| 120 | 8. 0 | 195 | 13. 0 | 270 | 18. 0 | 345 | 23. 0 |
| 125 | 8.20 | 200 | 13.20 | 275 | 18.20 | 350 | 23.20 |
| 130 | 8.40 | 205 | 13.40 | 280 | 18.40 | 355 | 23.40 |
| 135 | 9. 0 | 210 | 14. 0 | 285 | 19. 0 | 360 | 24. 0 |
| 140 | 9.20 | 215 | 14.20 | 290 | 19.20 | | |
| 145 | 9.40 | 220 | 14.40 | 295 | 19.40 | | |
| 150 | 10. 0 | 225 | 15. 0 | 300 | 20. 0 | | |
| 155 | 10.20 | 230 | 15.20 | 305 | 20.20 | | |
| 160 | 10.40 | 235 | 15.40 | 310 | 20.40 | | |
| 165 | 11. 0 | 240 | 16. 0 | 315 | 21. 0 | | |

## A Table of the Limits which the Difference of the Moon's and Star's Latitudes, if of the ſame Denomination, or Sum, if of contrary denomination, ſhould not exceed.

| Diſtance of the Moon from the Star, or the Difference of their Longitudes. | Limits for the Difference, or Sum, of the Latitudes. |
|---|---|
| 9 | 0 |
| 10 | 1 |
| 15 | 2 |
| 20 | 2½ |
| 25 | 3½ |
| 30 | 4 |
| 35 | 5 |
| 40 | 6 |
| 45 | 7 |
| 50 | 8 |
| 60 | 12 |
| 70 | 20 |
| 80 | 36 |

## A Catalogue of the Longitudes and Latitudes of twelve Zodiacal Stars of the firſt and ſecond Magnitude, proper to meaſure the Diſtance of the Moon from, in order to determine the Longitude by Sea or Land. Adapted to the Beginning of the Year 1763.

*N. B.* The Longitude of the Stars in this Catalogue are to be corrected by the Addition of the Numbers in the next Table, and are alſo to be augmented at the Rate of 50″ ⅓ for every Year after 1763.

| Names of the Stars. | Cha. | Mag. | Longitude. s. | ° | ′ | ″ | Latitude. ° | ′ | ″ | |
|---|---|---|---|---|---|---|---|---|---|---|
| Extremity of the Wing of Pegaſus, *Algenib* - - - | γ | 2 | 0. | 5. | 51. | 13 | 12. | 35. | 6 | *N.* |
| The bright Star in the Jaw of the Whale - - - | α | 2 | 1. | 11. | 0. | 29 | 12. | 36. | 16 | *S.* |
| The South Eye of the Bull, *Aldebaran.* A red Star | α | 1 | 2. | 6. | 28. | 31 | 5. | 29. | 9 | *S.* |
| The North Horn of the Bull - - - - - - - - | β | 2 | 2. | 19. | 15. | 46 | 5. | 21. | 55 | *N.* |
| The Southernmoſt of the Twins, *Pollux* - - - - | β | 2 | 3. | 19. | 56. | 50 | 6. | 39. | 55 | *N.* |
| The Lyon's Heart, *Regulus.* A red Star - - - | α | 1 | 4. | 26. | 32. | 8 | 0. | 27. | 20 | *N.* |
| The Virgin's Spike - - - - - - - - - - - - | α | 1 | 6. | 20. | 3[illegible] | 1 | 2. | 2. | 9 | *S.* |
| The Scorpion's Heart, *Antares.* A red Star - - | α | 1 | 8. | 6. | 26. | 59 | 4. | 32. | 35 | *S.* |
| In the Southern Part of the Bow of Sagittary - - | ε | 2 | 9. | 1. | 46. | 7 | 11. | 0. | 25 | *S.* |
| In the Head of Capricorn - - - - - - - - | α | 2 | 10. | 0. | 26. | 53 | 6. | 58. | 29 | *N.* |
| Bright Star in the mouth of the ſouthern fiſh, *Fomalhaut* | α | 1 | 11. | 0. | 31. | 12 | 21. | 6. | 13 | *S.* |
| In the Wing of Pegaſus, *Markab* - - - - - - | α | 1 | 11. | 20. | 10. | 53 | 19. | 24. | 46 | *N.* |

## A Table of the Semidiameter and Hourly Motion of the Sun ; and of the Corrections of the Longitudes of the Zodiacal Stars, for every 10th Day in the Year.

| Days of the Month. | Semidiameter of the Sun. | Hourly Motion of the Sun. | α Wing of Pegaſus Algen. | α Jaw of the Whale. | α Bull's S. Eye, Aldebaran. | β North Horn of the Bull | β South Twin Pollux. | α Lyon's Heart Regulus. | α The virgin's Spike. | α The Scorpion's Heart Antares | ε In Bow of Sagittary. | α Head of Capricorn | α Mouth of S. ſiſh Fomalhaut | α Wing of Pegaſus. Mark. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ′ ″ | ′ ″ | ″ | ″ | ″ | ″ | ″ | ″ | | | | | | |
| Jan. 1 | 16. 21 | 2. 33 | 8 | 15 | 18 | 18 | 20 | 14 | 0 | 0 | 0 | 0 | 2 | 6 |
| 10 | 16. 21 | 2. 33 | 6 | 13 | 17 | 18 | 21 | 17 | 4 | 3 | 2 | 0 | 1 | 4 |
| 20 | 16. 20 | 2. 33 | 5 | 11 | 17 | 18 | 23 | 21 | 9 | 8 | 6 | 2 | 1 | 3 |
| Feb. 1 | 16. 18 | 2. 32 | 2 | 8 | 14 | 16 | 22 | 23 | 14 | 12 | 9 | 3 | 0 | 1 |
| 10 | 16. 17 | 2. 32 | 1 | 6 | 12 | 14 | 22 | 25 | 18 | 16 | 12 | 5 | 0 | 0 |
| 20 | 16. 15 | 2. 31 | 0 | 5 | 11 | 13 | 22 | 27 | 23 | 22 | 17 | 9 | 2 | 1 |
| Mar. 1 | 16. 13 | 2. 30 | 0 | 3 | 8 | 11 | 21 | 27 | 26 | 26 | 21 | 12 | 3 | 1 |
| 10 | 16. 10 | 2. 29 | 0 | 1 | 6 | 9 | 19 | 27 | 29 | 30 | 25 | 15 | 5 | 2 |
| 20 | 16. 7 | 2. 29 | 1 | 1 | 5 | 7 | 18 | 28 | 33 | 35 | 30 | 20 | 9 | 4 |
| Apr. 1 | 16. 4 | 2. 28 | 2 | 0 | 2 | 4 | 15 | 26 | 35 | 40 | 35 | 25 | 12 | 6 |
| 10 | 16. 2 | 2. 27 | 5 | 0 | 2 | 3 | 14 | 26 | 37 | 44 | 40 | 30 | 16 | 10 |
| 20 | 15. 59 | 2. 26 | 7 | 0 | 1 | 2 | 12 | 24 | 38 | 47 | 44 | 34 | 20 | 13 |
| May 1 | 15. 56 | 2. 25 | 10 | 1 | 0 | 0 | 9 | 21 | 38 | 50 | 49 | 39 | 25 | 16 |
| 10 | 15. 54 | 2. 25 | 14 | 3 | 1 | 1 | 8 | 20 | 38 | 53 | 53 | 44 | 30 | 21 |
| 20 | 15. 53 | 2. 24 | 17 | 5 | 1 | 0 | 6 | 18 | 37 | 55 | 56 | 48 | 34 | 25 |
| June 1 | 15. 51 | 2. 23 | 23 | 9 | 3 | 1 | 5 | 16 | 37 | 57 | 60 | 53 | 39 | 31 |
| 10 | 15. 50 | 2. 23 | 27 | 12 | 5 | 2 | 5 | 14 | 35 | 57 | 61 | 56 | 44 | 35 |
| 20 | 15. 49 | 2. 23 | 31 | 15 | 7 | 3 | 4 | 12 | 33 | 57 | 63 | 59 | 48 | 39 |
| July 1 | 15. 49 | 2. 23 | 36 | 20 | 10 | 6 | 5 | 11 | 32 | 58 | 65 | 63 | 53 | 45 |
| 10 | 15. 49 | 2. 23 | 40 | 23 | 13 | 9 | 6 | 10 | 30 | 57 | 65 | 65 | 56 | 48 |
| 20 | 15. 50 | 2. 23 | 44 | 28 | 17 | 11 | 7 | 10 | 28 | 55 | 65 | 66 | 59 | 52 |
| Aug. 1 | 15. 51 | 2. 23 | 50 | 33 | 22 | 16 | 10 | 10 | 26 | 54 | 65 | 68 | 63 | 57 |
| 10 | 15. 53 | 2. 24 | 53 | 37 | 26 | 20 | 12 | 10 | 24 | 52 | 64 | 68 | 64 | 60 |
| 20 | 15. 55 | 2. 25 | 58 | 42 | 31 | 25 | 16 | 12 | 23 | 51 | 63 | 69 | 67 | 63 |
| Sept. 1 | 15. 57 | 2. 25 | 61 | 47 | 36 | 30 | 20 | 13 | 21 | 48 | 61 | 68 | 68 | 66 |
| 10 | 15. 59 | 2. 26 | 63 | 51 | 40 | 34 | 24 | 15 | 20 | 46 | 59 | 66 | 68 | 67 |
| 20 | 16. 2 | 2. 27 | 66 | 56 | 45 | 39 | 29 | 19 | 21 | 45 | 57 | 65 | 69 | 69 |
| Oct. 1 | 16. 5 | 2. 28 | 67 | 59 | 50 | 43 | 33 | 22 | 21 | 43 | 55 | 63 | 68 | 69 |
| 10 | 16. 7 | 2. 28 | 69 | 62 | 54 | 48 | 38 | 26 | 22 | 42 | 54 | 62 | 68 | 70 |
| 20 | 16. 10 | 2. 29 | 69 | 64 | 58 | 52 | 42 | 30 | 23 | 41 | 52 | 60 | 66 | 69 |
| Nov. 1 | 16. 13 | 2. 30 | 69 | 67 | 62 | 57 | 48 | 36 | 26 | 40 | 50 | 58 | 64 | 68 |
| 10 | 16. 15 | 2. 31 | 68 | 68 | 64 | 60 | 52 | 40 | 27 | 40 | 49 | 56 | 62 | 67 |
| 20 | 16. 17 | 2. 32 | 66 | 68 | 66 | 63 | 56 | 44 | 31 | 40 | 47 | 54 | 60 | 64 |
| Dec. 1 | 16. 19 | 2. 32 | 65 | 69 | 68 | 66 | 61 | 50 | 36 | 42 | 48 | 52 | 58 | 63 |
| 10 | 16. 20 | 2. 33 | 63 | 68 | 69 | 67 | 64 | 54 | 40 | 44 | 48 | 51 | 56 | 60 |
| 20 | 16. 21 | 2. 33 | 61 | 67 | 69 | 69 | 68 | 60 | 45 | 47 | 49 | 51 | 54 | 59 |
| 31 | 16. 21 | 2. 33 | 58 | 65 | 68 | 68 | 70 | 64 | 50 | 50 | 50 | 50 | 52 | 56 |

## Tables of the Sun and Moon.

### Tables of the Sun for the Meridian of the Royal Obſervatory at *Greenwich*.

### Epochs of the Sun's mean Longitude for the Beginning of the Year.

| Years. | Mean Long. ☉ | Long. Apog. |
|---|---|---|
| | s. ° ′ ″ | s. ° ′ ″ |
| L 1760 | 9. 10. 35. 8 | 3. 8. 47. 25 |
| 1761 | 9. 10. 20. 48 | 48. 30 |
| 1762 | 9. 10. 6. 28 | 49. 35 |
| 1763 | 9. 9. 52. 8 | 50. 40 |
| L. 1764 | 9. 10. 36. 57 | 51. 45 |
| 1765 | 9. 10. 22. 37 | 52. 50 |
| 1766 | 9. 10. 8. 17 | 53. 55 |
| 1767 | 9. 9. 53. 58 | 55. 0 |
| L. 1768 | 9. 10. 38. 46 | 56. 5 |
| 1769 | 9. 10. 24. 26 | 57. 10 |
| 1770 | 9. 10. 10. 7 | 58. 15 |
| 1771 | 9. 9. 55. 47 | 3. 8. 59 20 |
| L. 1772 | 9. 10. 40. 35 | 3. 9. 0. 25 |
| 1773 | 9. 10. 26. 16 | 1. 30 |
| 1774 | 9. 10. 11. 56 | 2. 35 |
| 1775 | 9. 9. 57. 36 | 3. 40 |
| L. 1776 | 9. 10. 42. 25 | 4. 45 |
| 1777 | 9. 10. 28. 5 | 5. 50 |
| 1778 | 9. 10. 13. 45 | 6. 55 |
| 1779 | 9. 9. 59. 25 | 8. 0 |
| L. 1780 | 9. 10. 44. 14 | 9. 5 |

### Motion of the Sun to the Beginning of each Month.

| Months | Mean Mot. of ☉ | Mot. of Apog. |
|---|---|---|
| | s ° ′ ″ | ″ |
| Jan. | 0. 0. 0. 0 | 0 |
| Feb. | 1. 0. 33. 18 | 5 |
| March | 1. 28. 9. 11 | 10 |
| April | 2. 28. 42. 30 | 16 |
| May | 3. 28. 16. 40 | 21 |
| June | 4. 28. 49. 58 | 27 |
| July | 5. 28. 24. 8 | 32 |
| Auguſt | 6. 28. 57. 26 | 38 |
| Sept. | 7. 29. 30. 44 | 43 |
| October | 8. 29. 4. 54 | 49 |
| Nov. | 9. 29. 38. 12 | 54 |
| Dec. | 10. 29. 12. 22 | 59 |

### Motion of the Sun for Days of the Month.

| Days | Mo. of Sun. | M. Ap. |
|---|---|---|
| | ° ′ ″ | |
| 1 | 0. 59. 8 | 0 |
| 2 | 1. 58. 17 | 0 |
| 3 | 2. 57. 25 | 0 |
| 4 | 3. 56. 33 | 1 |
| 5 | 4. 55. 42 | 1 |
| 6 | 5. 54. 50 | 1 |
| 7 | 6. 53. 58 | 1 |
| 8 | 7. 53. 7 | 1 |
| 9 | 8. 52. 15 | 2 |
| 10 | 9. 51. 23 | 2 |
| 11 | 10. 50. 32 | 2 |
| 12 | 11. 49. 40 | 2 |
| 13 | 12. 48. 48 | 2 |
| 14 | 13. 47. 57 | 3 |
| 15 | 14. 47. 5 | 3 |
| 16 | 15. 46. 13 | 3 |
| 17 | 16. 45. 22 | 3 |
| 18 | 17. 44. 30 | 3 |
| 19 | 18. 43. 38 | 3 |
| 20 | 19. 42. 47 | 3 |
| 21 | 20. 41. 55 | 4 |
| 22 | 21. 41. 3 | 4 |
| 23 | 22. 40. 12 | 4 |
| 24 | 23. 39. 20 | 4 |
| 25 | 24. 38. 28 | 4 |
| 26 | 25. 37. 37 | 5 |
| 27 | 26. 36. 45 | 5 |
| 28 | 27. 35. 53 | 5 |
| 29 | 28. 35. 2 | 5 |
| 30 | 29. 34. 10 | 5 |
| | s. ° ′ ″ | 5 |
| 31 | 1. 0. 33. 18 | 1 |

In the Months of January and Feb. in Leap Year, compute for the Day preceding the given Day.

### Motion of the Sun for Hours, Min. and Sec.

| S.<br>M<br>H | ‴ ⁗<br>″ ‴<br>′ ″ | S.<br>M | ″ ‴<br>′ ″ |
|---|---|---|---|
| 1 | 2. 28 | 25 | 1. 2 |
| 2 | 4. 56 | 26 | 1. 4 |
| 3 | 7. 23 | 27 | 1. 6 |
| 4 | 9. 51 | 28 | 1. 9 |
| 5 | 12. 19 | 29 | 1. 11 |
| | | 30 | 1. 14 |
| 6 | 14. 47 | 31 | 1. 16 |
| 7 | 17. 15 | 32 | 1. 19 |
| 8 | 19. 43 | 33 | 1. 21 |
| 9 | 22. 11 | 34 | 1. 24 |
| 10 | 24. 38 | 35 | 1. 26 |
| 11 | 27. 6 | 36 | 1. 29 |
| 12 | 29. 34 | 37 | 1. 31 |
| 13 | 32. 2 | 38 | 1. 34 |
| 14 | 34. 30 | 39 | 1. 36 |
| 15 | 36. 58 | 40 | 1. 38 |
| 16 | 39. 26 | 41 | 1. 41 |
| 17 | 41. 53 | 42 | 1. 43 |
| 18 | 44. 21 | 43 | 1. 46 |
| 19 | 46. 49 | 44 | 1. 48 |
| 20 | 49. 17 | 45 | 1. 51 |
| 21 | 51. 45 | 46 | 1. 53 |
| 22 | 54. 13 | 47 | 1. 56 |
| 23 | 56. 40 | 48 | 1. 58 |
| 24 | 59. 8 | 49 | 2. 1 |
| | | 50 | 2. 3 |
| | | 51 | 2. 6 |
| | | 52 | 2. 8 |
| | | 53 | 2. 11 |
| | | 54 | 2. 13 |
| | | 55 | 2. 15 |
| | | 56 | 2. 18 |
| | | 57 | 2. 20 |
| | | 58 | 2. 23 |
| | | 59 | 2. 25 |
| | | 60 | 2. 28 |

## Equation of the Sun's Center.

## Argum. The mean Anomaly of the Sun.

| | 0 | | 1 | | 2 | | |
|---|---|---|---|---|---|---|---|
| | — | Diff. | — | Diff. | — | Diff. | |
| | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | |
| 0 | 0. 0. 0 | 1. 59 | 0. 56. 43 | 1. 42 | 1. 38. 58 | 1. 1 | 30 |
| 1 | 0. 1. 59 | 1. 59 | 0. 58. 25 | 1. 41 | 1. 39. 59 | 0. 59 | 29 |
| 2 | 0. 3. 58 | 1. 58 | 1. 0. 6 | 1. 41 | 1. 40. 58 | 0. 57 | 28 |
| 3 | 0. 5. 56 | 1. 58 | 1. 1. 47 | 1. 40 | 1. 41. 55 | 0. 55 | 27 |
| 4 | 0. 7. 54 | 1. 58 | 1. 3. 27 | 1. 39 | 1. 42. 50 | 0. 54 | 26 |
| 5 | 0. 9. 52 | 1. 58 | 1. 5. 6 | 1. 38 | 1. 43. 44 | 0. 52 | 25 |
| 6 | 0. 11. 50 | 1. 58 | 1. 6. 44 | 1. 37 | 1. 44. 36 | 0. 50 | 24 |
| 7 | 0. 13. 48 | 1. 57 | 1. 8. 21 | 1. 36 | 1. 45. 26 | 0. 48 | 23 |
| 8 | 0. 15. 45 | 1. 57 | 1. 9. 57 | 1. 34 | 1. 46. 14 | 0. 46 | 22 |
| 9 | 0. 17. 42 | 1. 57 | 1. 11. 31 | 1. 33 | 1. 47. 0 | 0. 44 | 21 |
| 10 | 0. 19. 39 | 1. 57 | 1. 13. 4 | 1. 32 | 1. 47. 44 | 0. 42 | 20 |
| 11 | 0. 21. 36 | 1. 56 | 1. 14. 36 | 1. 30 | 1. 48. 26 | 0. 40 | 19 |
| 12 | 0. 23. 32 | 1. 56 | 1. 16. 6 | 1. 29 | 1. 49. 6 | 0. 38 | 18 |
| 13 | 0. 25. 28 | 1. 55 | 1. 17. 35 | 1. 27 | 1. 49. 44 | 0. 36 | 17 |
| 14 | 0. 27. 23 | 1. 55 | 1. 19. 2 | 1. 26 | 1. 50. 20 | 0. 35 | 16 |
| 15 | 0. 29. 18 | 1. 54 | 1. 20. 28 | 1. 25 | 1. 50. 55 | 0. 33 | 15 |
| 16 | 0. 31. 12 | 1. 54 | 1. 21. 53 | 1. 23 | 1. 51. 28 | 0. 31 | 14 |
| 17 | 0. 33. 6 | 1. 53 | 1. 23. 16 | 1. 22 | 1. 51. 59 | 0. 29 | 13 |
| 18 | 0. 34. 59 | 1. 53 | 1. 24. 38 | 1. 20 | 1. 52. 28 | 0. 27 | 12 |
| 19 | 0. 36. 52 | 1. 52 | 1. 25. 58 | 1. 19 | 1. 52. 55 | 0. 24 | 11 |
| 20 | 0. 38. 44 | 1. 51 | 1. 27. 17 | 1. 17 | 1. 53. 19 | 0. 22 | 10 |
| 21 | 0. 40. 35 | 1. 51 | 1. 28. 34 | 1. 16 | 1. 53. 41 | 0. 20 | 9 |
| 22 | 0. 42. 26 | 1. 50 | 1. 29. 50 | 1. 14 | 1. 54. 1 | 0. 18 | 8 |
| 23 | 0. 44. 16 | 1. 49 | 1. 31. 4 | 1. 13 | 1. 54. 19 | 0. 16 | 7 |
| 24 | 0. 46. 5 | 1. 49 | 1. 32. 17 | 1. 11 | 1. 54. 35 | 0. 15 | 6 |
| 25 | 0. 47. 54 | 1. 48 | 1. 33. 28 | 1. 9 | 1. 54. 50 | 0. 12 | 5 |
| 26 | 0. 49. 42 | 1. 47 | 1. 34. 37 | 1. 8 | 1. 55. 2 | 0. 10 | 4 |
| 27 | 0. 51. 29 | 1. 46 | 1. 35. 45 | 1. 6 | 1. 55. 12 | 0. 8 | 3 |
| 28 | 0. 53. 15 | 1. 45 | 1. 36. 51 | 1. 4 | 1. 55. 20 | 0. 6 | 2 |
| 29 | 0. 54. 0 | 1. 43 | 1. 37. 55 | 1. 2 | 1. 55. 26 | 0. 3 | 1 |
| 30 | 0. 56. 43 | | 1. 38. 58 | | 1. 55. 29 | | 0 |
| | + | | + | | + | | |
| | 11 | | 10 | | 9 | | |

## Equation of the Sun's Center.
## Argum. The mean Anomaly of the Sun.

| | 3 | | 4 | | 5 | | |
|---|---|---|---|---|---|---|---|
| | — | Diff. | — | Diff. | — | Diff. | |
| | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | |
| 0 | 1. 55. 29 | 0. 1 | 1. 41. 4 | 1. 0 | 0. 58. 49 | 1. 47 | 30 |
| 1 | 1. 55. 30 | 0. 1 | 1. 40. 4 | 1. 2 | 0. 57. 2 | 1. 48 | 29 |
| 2 | 1. 55. 29 | 0. 3 | 1. 39. 2 | 1. 4 | 0. 55. 14 | 1. 49 | 28 |
| 3 | 1. 55. 26 | 0. 5 | 1. 37. 58 | 1. 6 | 0. 53. 25 | 1. 50 | 27 |
| 4 | 1. 55. 21 | 0. 6 | 1. 36. 52 | 1. 7 | 0. 51. 35 | 1. 50 | 26 |
| 5 | 1. 55. 15 | 0. 9 | 1. 35. 45 | 1. 10 | 0. 49. 45 | 1. 51 | 25 |
| 6 | 1. 55. 6 | 0. 11 | 1. 34. 35 | 1. 11 | 0. 47. 54 | 1. 52 | 24 |
| 7 | 1. 54. 55 | 0. 13 | 1. 33. 24 | 1. 13 | 0. 46. 2 | 1. 53 | 23 |
| 8 | 54. 42 | 0. 16 | 1. 32. 11 | 1. 15 | 0. 44. 9 | 1. 55 | 22 |
| 9 | 1. 54. 26 | 0. 18 | 1. 30. 56 | 1. 16 | 0. 42. 14 | 1. 56 | 21 |
| 10 | 1. 54. 8 | 0. 20 | 1. 29. 40 | 1. 18 | 0. 40. 18 | 1. 56 | 20 |
| 11 | 1. 53. 48 | 0. 22 | 1. 28. 22 | 1. 20 | 0. 38. 22 | 1. 57 | 19 |
| 12 | 1. 53. 26 | 0. 24 | 1. 27. 2 | 1. 21 | 0. 36. 25 | 1. 57 | 18 |
| 13 | 1. 53. 2 | 0. 26 | 1. 25. 41 | 1. 23 | 0. 34. 28 | 1. 58 | 17 |
| 14 | 1. 52. 36 | 0. 27 | 1. 24. 18 | 1. 25 | 0. 32. 30 | 1. 59 | 16 |
| 15 | 1. 52. 9 | 0. 30 | 1. 22. 53 | 1. 26 | 0. 30. 31 | 1. 59 | 15 |
| 16 | 1. 51. 39 | 0. 32 | 1. 21. 27 | 1. 28 | 0. 28. 32 | 2. 0 | 14 |
| 17 | 1. 51. 7 | 0. 34 | 1. 19. 59 | 1. 29 | 0. 26. 32 | 2. 0 | 13 |
| 18 | 1. 50. 33 | 0. 36 | 1. 18. 30 | 1. 31 | 0. 24. 32 | 2. 1 | 12 |
| 19 | 1. 49. 57 | 0. 39 | 1. 16. 59 | 1. 32 | 0. 22. 31 | 2. 2 | 11 |
| 20 | 1. 49. 18 | 0. 41 | 1. 15. 27 | 1. 34 | 0. 20. 29 | 2. 2 | 10 |
| 21 | 1. 48. 37 | 0. 43 | 1. 13. 53 | 1. 35 | 0. 18. 27 | 2. 2 | 9 |
| 22 | 1. 47. 54 | 0. 44 | 1. 12. 18 | 1. 37 | 0. 16. 25 | 2. 2 | 8 |
| 23 | 1. 47. 10 | 0. 46 | 1. 10. 41 | 1. 38 | 0. 14. 23 | 2. 3 | 7 |
| 24 | 1. 46. 24 | 0. 48 | 1. 9. 3 | 1. 39 | 0. 12. 20 | 2. 3 | 6 |
| 25 | 1. 45. 36 | 0. 50 | 1. 7. 24 | 1. 40 | 0. 10. 17 | 2. 3 | 5 |
| 26 | 1. 44. 46 | 0. 52 | 1. 5. 44 | 1. 42 | 0. 8. 14 | 2. 3 | 4 |
| 27 | 1. 43. 54 | 0. 54 | 1. 4. 2 | 1. 43 | 0. 6. 11 | 2. 3 | 3 |
| 28 | 1. 43. 0 | 0. 57 | 1. 2. 19 | 1. 44 | 0. 4. 8 | 2. 4 | 2 |
| 29 | 1. 42. 3 | 0. 59 | 1. 0. 35 | 1. 46 | 0. 2. 4 | 2. 4 | 1 |
| 30 | 1. 41. 4 | | 0. 58. 49 | | 0. 0. 0 | | 0 |
| | + | | + | | + | | |
| | 8 | | 7 | | 6 | | |

## A Table of the Equation of Time.

### Longitude of the Sun.

| S. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | ± | − | ∓ | + | + | ± | − | − | − | ∓ | + | + |
| D | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ |
| 0 | 7.36 | 1. 9 | 3.51 | 1.13 | 5.57 | 2.20 | 7.38 | 15.31 | 13.33 | 1.11 | 11.28 | 14.19 |
| 1 | 7.17 | 1.23 | 3.47 | 1.26 | 5.59 | 2. 4 | 7.58 | 15.39 | 13.17 | 0.42 | 11.45 | 14.13 |
| 2 | 6.58 | 1.36 | 3.42 | 1.40 | 6. 0 | 1.48 | 8.19 | 15.46 | 13. 0 | −.12 | 12. 1 | 14. 6 |
| 3 | 6.39 | 1.48 | 3.37 | 1.53 | 6. 1 | 1.31 | 8.40 | 15.52 | 12.42 | +.17 | 12.17 | 13.59 |
| 4 | 6.20 | 2.00 | 3.32 | 2. 7 | 6. 1 | 1.14 | 9. 1 | 15.57 | 12.23 | 0.46 | 12.32 | 13.51 |
| 5 | 6. 1 | 2.11 | 3.26 | 2.20 | 6. 0 | 0.56 | 9.21 | 16. 2 | 12. 4 | 1.16 | 12.46 | 13.43 |
| 6 | 5.42 | 2.22 | 3.19 | 2.33 | 5.59 | 0.38 | 9.41 | 16. 6 | 11.44 | 1.45 | 12.59 | 13.34 |
| 7 | 5.24 | 2.32 | 3.12 | 2.45 | 5.57 | 0.20 | 10. 1 | 16. 9 | 11.23 | 2.14 | 13.12 | 13.24 |
| 8 | 5. 5 | 2.42 | 3. 4 | 2.58 | 5.54 | +. 1 | 10.20 | 16.11 | 11. 1 | 2.43 | 13.24 | 13.14 |
| 9 | 4.47 | 2.51 | 2.56 | 3.11 | 5.51 | −.18 | 10.39 | 16.13 | 10.39 | 3.11 | 13.35 | 13. 3 |
| 10 | 4.28 | 3. 0 | 2.47 | 3.23 | 5.47 | 0.37 | 10.57 | 16.13 | 10.16 | 3.39 | 13.45 | 12.51 |
| 11 | 4. 9 | 3. 8 | 2.38 | 3.35 | 5.42 | 0.57 | 11.15 | 16.13 | 9.53 | 4. 7 | 13.54 | 12.39 |
| 12 | 3.50 | 3.16 | 2.29 | 3.46 | 5.37 | 1.17 | 11.33 | 16.12 | 9.29 | 4.35 | 14. 2 | 12.27 |
| 13 | 3.32 | 3.23 | 2.19 | 3.58 | 5.31 | 1.38 | 11.51 | 16.10 | 9. 5 | 5. 2 | 14. 9 | 12.14 |
| 14 | 3.13 | 3.30 | 2. 8 | 4. 9 | 5.24 | 1.58 | 12. 8 | 16. 7 | 8.40 | 5.29 | 14.16 | 12. 0 |
| 15 | 2.55 | 3.36 | 1.57 | 4.19 | 5.17 | 2.19 | 12.25 | 16. 4 | 8.14 | 5.56 | 14.22 | 11.46 |
| 16 | 2.37 | 3.41 | 1.46 | 4.29 | 5. 9 | 2.40 | 12.41 | 16. 0 | 7.48 | 6.22 | 14.27 | 11.31 |
| 17 | 2.19 | 3.46 | 1.35 | 4.39 | 5. 1 | 3. 1 | 12.57 | 15.55 | 7.22 | 6.48 | 14.31 | 11.16 |
| 18 | 2. 1 | 3.50 | 1.23 | 4.48 | 4.52 | 3.22 | 13.12 | 15.49 | 6.55 | 7.13 | 14.35 | 11. 1 |
| 19 | 1.43 | 3.53 | 1.11 | 4.57 | 4.43 | 3.44 | 13.27 | 15.42 | 6.28 | 7.37 | 14.38 | 10.46 |
| 20 | 1.26 | 3.56 | 0.59 | 5. 5 | 4.33 | 4. 5 | 13 42 | 15.35 | 6. 0 | 8. 1 | 14.40 | 10.30 |
| 21 | 1. 9 | 3.58 | 0.46 | 5.13 | 4.22 | 4.26 | 13.56 | 15.26 | 5.32 | 8.24 | 14.41 | 10.14 |
| 22 | 0.52 | 4. 0 | 0.34 | 5.20 | 4.11 | 4.47 | 14. 9 | 15.17 | 5. 4 | 8.47 | 14.42 | 9.58 |
| 23 | 0.36 | 4. 1 | 0.21 | 5.27 | 3.59 | 5. 9 | 14.21 | 15. 7 | 4.36 | 9. 9 | 14.41 | 9.41 |
| 24 | 0.20 | 4. 1 | −.8 | 5.33 | 3.46 | 5.30 | 14.33 | 14.56 | 4. 8 | 9.31 | 14.40 | 9.24 |
| 25 | +. 4 | 4. 1 | +.5 | 5.39 | 3.33 | 5.52 | 14.44 | 14.44 | 3.39 | 9.53 | 14.39 | 9. 6 |
| 26 | −.11 | 4. 0 | 0.19 | 5.44 | 3.19 | 6.13 | 14.55 | 14.31 | 3.10 | 10.14 | 14.37 | 8.48 |
| 27 | 0.26 | 3.59 | 0.32 | 5.48 | 3. 4 | 6.35 | 15. 5 | 14.17 | 2.41 | 10.34 | 14.34 | 8.30 |
| 28 | 0.40 | 3.57 | 0.46 | 5.52 | 2.50 | 6.56 | 15.14 | 14. 3 | 2.11 | 10.53 | 14.30 | 8.12 |
| 29 | 0.55 | 3.54 | 0.59 | 5.55 | 2.35 | 7.17 | 15.23 | 13.48 | 1.41 | 11.11 | 14.25 | 7.54 |
| 30 | 1. 9 | 3.51 | 1.13 | 5.57 | 2.20 | 7.38 | 15.31 | 13.33 | 1.11 | 11.28 | 14.19 | 7.36 |

The Equations marked + are to be added to apparent Time; and thoſe marked − are to be ſubſtracted from apparent Time to find mean time.

# Tables of the Moon for the Meridian of the Royal Obſervatory at *Greenwich*.

Epochs of the Moon's mean Longitude. Mean Anomaly and Longitude of aſcending Node, for the Beginning of the Year.

| Years. | Mean Lo. ☽ | Mean An. ☽ | Long. of ☊ |
|---|---|---|---|
| | s ° ′ ″ | s ° ′ ″ | s ° ′ ″ |
| L 1760 | 2.21.44.59 | 7.13.50.27 | 2.26.52. 6 |
| 1761 | 7. 1. 8. 4 | 10.12.33.40 | 2. 7.32.25 |
| 1762 | 11.10.31. 9 | 1.11.16.53 | 1.18.12.43 |
| 1763 | 3.19.54.15 | 4.10. 0. 6 | 0.28.53. 2 |
| L.1764 | 8.12.27.55 | 7.21.47.13 | 0. 9.30.10 |
| 1765 | 0.21.51. 0 | 10.20.30.26 | 11.20.10.29 |
| 1766 | 5. 1.14. 6 | 1.19.13.39 | 11. 0.50.48 |
| 1767 | 9.10.37.11 | 4.17.56.52 | 10.11.31. 6 |
| L.1768 | 2. 3.10.51 | 7.29.43.59 | 9.22. 8.15 |
| 1769 | 6.12.33.57 | 10.28 27.12 | 9. 2.48.33 |
| 1770 | 10.21.57. 2 | 1.27.10.25 | 8.13.28.52 |
| 1771 | 3. 1.20. 7 | 4.25.53.38 | 7.24. 9.11 |
| L.1772 | 7.23.53.48 | 8. 7.40.45 | 7. 4.46.19 |
| 1773 | 0. 3.16.53 | 11. 6.23.58 | 6.15.26.38 |
| 1774 | 4.12.39.58 | 2. 5. 7.11 | 5.26. 6.57 |
| 1775 | 8.22. 3. 4 | 5. 3.50.24 | 5. 6.47.15 |
| L.1776 | 1.14.36.44 | 8.15.37.31 | 4.17.24.23 |
| 1777 | 5.23.59.49 | 11.14.20.44 | 3.28. 4 42 |
| 1778 | 10. 3.22.55 | 2.13. 3.57 | 3. 8.45. 1 |
| 1779 | 2.12.46. 0 | 5.11.47.10 | 2.19.25.20 |
| L.1780 | 7. 5 19.41 | 8.23.34.17 | 2. 0. 2.28 |

Mean Motion of the Moon, Motion of mean Anomaly, and Node, to the Beginning of each Month.

| Months | Mean Mo. ☽ | Mo. Mn An. | Motion of ☊ |
|---|---|---|---|
| | s ° ′ ″ | s ° ′ ″ | ° ′ ″ |
| Jan. | 0. 0. 0. 0 | 0. 0. 0. 0 | 0. 0. 0 |
| Feb. | 1.18.28. 6 | 1.15. 0.53 | 1. 38. 30 |
| March | 1.27.24.27 | 1.20.50. 3 | 3. 7. 27 |
| April | 3.15.52.33 | 3. 5.50.56 | 4. 45. 57 |
| May | 4.21.10. 3 | 4. 7.47.54 | 6. 21. 16 |
| June | 6. 9.38. 9 | 5.22.48.47 | 7. 59. 46 |
| July | 7.14.55.40 | 6.24.45.46 | 9. 35. 5 |
| Auguſt | 9. 3.23.46 | 8. 9.46.38 | 11. 13. 34 |
| Sept. | 10.21.51.52 | 9.24.47.31 | 12. 52. 4 |
| October | 11.27. 9.23 | 10.26.44.29 | 14. 27. 23 |
| Nov. | 1.15.37.29 | 0.11.45.22 | 16. 5. 53 |
| Dec. | 2.20.54.59 | 1.13.42.20 | 17. 41. 12 |

Mean Motion of the Moon, Motion of mean Anomaly, and Node for Days of of the Month.

| Days. | Mean Mo. ☽ | Mo. Mn An. | Motion of ☊ |
|---|---|---|---|
| | s ° ′ ″ | s ° ′ ″ | ° ′ ″ |
| 1 | 0.13.10.35 | 0.13. 3.54 | 0. 3. 11 |
| 2 | 0.26.21.10 | 0.26. 7.48 | 0. 6. 21 |
| 3 | 1. 9.31.45 | 1. 9.11 42 | 0. 9. 32 |
| 4 | 1.22.42.20 | 1.22.15.36 | 0. 12. 43 |
| 5 | 2. 5.52.55 | 2. 5.19.30 | 0. 15. 53 |
| 6 | 2.19. 3.30 | 2.18.23 24 | 0. 19. 4 |
| 7 | 3. 2.14. 5 | 3. 1.27.18 | 0. 22. 14 |
| 8 | 3 15.24.40 | 3.14.31.12 | 0. 25. 25 |
| 9 | 3.28.35.15 | 3.27.35. 6 | 0. 28. 36 |
| 10 | 4.11.45.50 | 4.10.39. 0 | 0. 31. 46 |
| 11 | 4.24.56.25 | 4.23.42.53 | 0. 34. 57 |
| 12 | 5. 8. 7. 0 | 5. 6.46.47 | 0. 38. 7 |
| 13 | 5.21.17.35 | 5.19.50.41 | 0. 41. 18 |
| 14 | 6. 4.28.10 | 6. 2.54.35 | 0. 44. 29 |
| 15 | 6.17.38.45 | 6.15.58.29 | 0. 47. 40 |
| 16 | 7. 0.49.20 | 6 29. 2.23 | 0. 50. 50 |
| 17 | 7.13.59.55 | 7.12. 6.17 | 0. 54. 1 |
| 18 | 7.27.10.30 | 7.25.10.11 | 0. 57. 11 |
| 19 | 8.10.21. 6 | 8. 8.14. 5 | 1. 0. 22 |
| 20 | 8.23.31.41 | 8.21.17.59 | 1. 3. 33 |
| 21 | 9. 6.42.16 | 9. 4 21.53 | 1. 6. 43 |
| 22 | 9.19.52.51 | 9.17.25.47 | 1. 9. 54 |
| 23 | 10. 3. 3.26 | 10. 0.29.41 | 1. 13. 5 |
| 24 | 10.16.14. 1 | 10.13.33.35 | 1. 16. 15 |
| 25 | 10.29.24.36 | 10.26.37.29 | 1. 19. 26 |
| 26 | 11.12.35.11 | 11. 9 41.23 | 1. 22. 36 |
| 27 | 11.25.45.46 | 11.22.45.17 | 1. 25. 47 |
| 28 | 0. 8.56.21 | 0. 5.49.11 | 1. 28. 58 |
| 29 | 0.22. 6.56 | 0.18.53. 5 | 1. 32. 8 |
| 30 | 1. 5.17.31 | 1. 1.56.59 | 1. 35. 19 |
| 31 | 1.18.28. 6 | 1.15. 0.53 | 1. 38. 30 |

In the Months of *January* and *February* in Leap-Year, compute for the Day preceding the given Day.

## A Table of the mean Motions of the Moon, Mean Anomaly, and Node for Hours, Minutes and Seconds.

|  | Mean Motion of the Moon. |  |  | Motion of mean Anomaly. |  |  | Motion of |  |  |  | Mean Motion of the Moon. |  |  | Motion of mean Anomaly. |  |  | Motion of |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| '' | '' | ''' | iv | '' | ''' | iv | '' | ''' | iv | '' | '' | ''' | iv | '' | ''' | iv | '' | ''' | iv |
| ' | ' | '' | ''' | ' | '' | ''' | ' | '' | ''' | ' | ' | '' | ''' | ' | '' | ''' | ' | '' | ''' |
| Ho. | ° | ' | '' | ° | ' | '' | ° | ' | '' | Ho. | ° | ' | '' | ° | ' | '' | ° | ' | '' |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 16 | 28 | 14 | 16 | 19 | 52 | 0 | 3 | 58 |
| 1 | 0 | 32 | 56 | 0 | 32 | 40 | 0 | 0 | 8 | 31 | 17 | 1 | 10 | 16 | 52 | 32 | 0 | 4 | 6 |
| 2 | 1 | 5 | 53 | 1 | 5 | 19 | 0 | 0 | 16 | 32 | 17 | 34 | 7 | 17 | 25 | 12 | 0 | 4 | 14 |
| 3 | 1 | 38 | 49 | 1 | 37 | 59 | 0 | 0 | 24 | 33 | 18 | 7 | 3 | 17 | 57 | 52 | 0 | 4 | 22 |
| 4 | 2 | 11 | 46 | 2 | 10 | 39 | 0 | 0 | 32 | 34 | 18 | 40 | 0 | 18 | 30 | 31 | 0 | 4 | 30 |
| 5 | 2 | 44 | 42 | 2 | 43 | 19 | 0 | 0 | 40 | 35 | 19 | 12 | 56 | 19 | 3 | 11 | 0 | 4 | 38 |
| 6 | 3 | 17 | 39 | 3 | 15 | 58 | 0 | 0 | 48 | 36 | 19 | 45 | 53 | 19 | 35 | 51 | 0 | 4 | 46 |
| 7 | 3 | 50 | 35 | 3 | 48 | 38 | 0 | 0 | 56 | 37 | 20 | 18 | 49 | 20 | 8 | 31 | 0 | 4 | 54 |
| 8 | 4 | 23 | 32 | 4 | 21 | 18 | 0 | 1 | 4 | 38 | 20 | 51 | 45 | 20 | 41 | 10 | 0 | 5 | 2 |
| 9 | 4 | 56 | 28 | 4 | 53 | 58 | 0 | 1 | 11 | 39 | 21 | 24 | 42 | 21 | 13 | 50 | 0 | 5 | 10 |
| 10 | 5 | 29 | 25 | 5 | 26 | 37 | 0 | 1 | 19 | 40 | 21 | 57 | 38 | 21 | 46 | 30 | 0 | 5 | 18 |
| 11 | 6 | 2 | 21 | 5 | 59 | 17 | 0 | 1 | 27 | 41 | 22 | 30 | 35 | 22 | 19 | 10 | 0 | 5 | 26 |
| 12 | 6 | 35 | 18 | 6 | 31 | 57 | 0 | 1 | 35 | 42 | 23 | 3 | 31 | 22 | 51 | 49 | 0 | 5 | 34 |
| 13 | 7 | 8 | 14 | 7 | 4 | 37 | 0 | 1 | 43 | 43 | 23 | 36 | 28 | 23 | 24 | 29 | 0 | 5 | 42 |
| 14 | 7 | 41 | 10 | 7 | 37 | 16 | 0 | 1 | 51 | 44 | 24 | 9 | 24 | 23 | 57 | 9 | 0 | 5 | 50 |
| 15 | 8 | 14 | 7 | 8 | 9 | 56 | 0 | 1 | 59 | 45 | 24 | 42 | 21 | 24 | 29 | 49 | 0 | 5 | 57 |
| 16 | 8 | 47 | 3 | 8 | 42 | 36 | 0 | 2 | 7 | 46 | 25 | 15 | 17 | 25 | 2 | 28 | 0 | 6 | 5 |
| 17 | 9 | 20 | 0 | 9 | 15 | 16 | 0 | 2 | 15 | 47 | 25 | 48 | 14 | 25 | 35 | 8 | 0 | 6 | 13 |
| 18 | 9 | 52 | 56 | 9 | 47 | 55 | 0 | 2 | 23 | 48 | 26 | 21 | 10 | 26 | 7 | 48 | 0 | 6 | 21 |
| 19 | 10 | 25 | 53 | 10 | 20 | 35 | 0 | 2 | 31 | 49 | 26 | 54 | 6 | 26 | 40 | 28 | 0 | 6 | 29 |
| 20 | 10 | 58 | 49 | 10 | 53 | 15 | 0 | 2 | 39 | 50 | 27 | 27 | 3 | 27 | 13 | 7 | 0 | 6 | 37 |
| 21 | 11 | 31 | 46 | 11 | 25 | 55 | 0 | 2 | 47 | 51 | 27 | 59 | 59 | 27 | 45 | 47 | 0 | 6 | 45 |
| 22 | 12 | 4 | 42 | 11 | 58 | 34 | 0 | 2 | 55 | 52 | 28 | 32 | 56 | 28 | 18 | 27 | 0 | 6 | 53 |
| 23 | 12 | 37 | 39 | 12 | 31 | 14 | 0 | 3 | 3 | 53 | 29 | 5 | 52 | 28 | 51 | 7 | 0 | 7 | 1 |
| 24 | 13 | 10 | 35 | 13 | 3 | 54 | 0 | 3 | 11 | 54 | 29 | 38 | 49 | 29 | 23 | 46 | 0 | 7 | 9 |
| 25 | 13 | 43 | 32 | 13 | 36 | 34 | 0 | 3 | 19 | 55 | 30 | 11 | 45 | 29 | 56 | 26 | 0 | 7 | 17 |
| 26 | 14 | 16 | 28 | 14 | 9 | 13 | 0 | 3 | 27 | 56 | 30 | 44 | 42 | 30 | 29 | 6 | 0 | 7 | 25 |
| 27 | 14 | 49 | 24 | 14 | 41 | 53 | 0 | 3 | 34 | 57 | 31 | 17 | 38 | 31 | 1 | 46 | 0 | 7 | 33 |
| 28 | 15 | 22 | 21 | 15 | 14 | 33 | 0 | 3 | 42 | 58 | 31 | 50 | 35 | 31 | 34 | 25 | 0 | 7 | 41 |
| 29 | 15 | 55 | 17 | 15 | 47 | 13 | 0 | 3 | 50 | 59 | 32 | 23 | 31 | 32 | 7 | 5 | 0 | 7 | 49 |
| 30 | 16 | 28 | 14 | 16 | 19 | 52 | 0 | 3 | 58 | 60 | 32 | 56 | 28 | 32 | 39 | 45 | 0 | 7 | 57 |

## Equations of the Moon.

### I. For the Longitude of the Moon.

Arg. I. Mean Anomaly of the Sun.
This Equation ſerves alſo for the Node and Double of it for the mean Anomaly.

| ° | 0 | 1 | 2 | 3 | 4 | 5 | ° |
|---|---|---|---|---|---|---|---|
|  | + | + | + | + | + | + |  |
| ° | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 5. 31 | 9. 40 | 11.20 | 9. 58 | 5. 49 | 30 |
| 1 | 0. 12 | 5. 41 | 9. 46 | 11.20 | 9. 52 | 5. 39 | 29 |
| 2 | 0. 24 | 5. 51 | 9. 52 | 11.20 | 9. 46 | 5. 28 | 28 |
| 3 | 0. 35 | 6. 1 | 9. 58 | 11.20 | 9. 39 | 5. 17 | 27 |
| 4 | 0. 47 | 6. 11 | 10. 3 | 11.19 | 9. 33 | 5. 6 | 26 |
| 5 | 0. 58 | 6. 21 | 10. 9 | 11.19 | 9. 26 | 4. 55 | 25 |
| 6 | 1. 10 | 6. 30 | 10.14 | 11.18 | 9. 19 | 4. 44 | 24 |
| 7 | 1. 21 | 6 40 | 10.19 | 11.17 | 9. 12 | 4. 33 | 23 |
| 8 | 1. 33 | 6. 49 | 10.24 | 11.16 | 9. 5 | 4. 22 | 22 |
| 9 | 1. 44 | 6. 58 | 10.29 | 11.15 | 8. 58 | 4. 11 | 21 |
| 10 | 1. 55 | 7. 7 | 10.33 | 11.13 | 8. 51 | 3. 59 | 20 |
| 11 | 2. 7 | 7. 16 | 10.37 | 11.11 | 8. 43 | 3. 48 | 19 |
| 12 | 2. 18 | 7. 25 | 10.41 | 11. 9 | 8. 35 | 3. 36 | 18 |
| 13 | 2. 29 | 7. 34 | 10.45 | 11. 7 | 8. 27 | 3. 25 | 17 |
| 14 | 2. 40 | 7. 42 | 10.49 | 11. 5 | 8. 19 | 3. 13 | 16 |
| 15 | 2. 51 | 7. 51 | 10.52 | 11. 2 | 8. 11 | 3. 1 | 15 |
| 16 | 3. 2 | 7. 59 | 10.55 | 10.59 | 8. 3 | 2. 50 | 14 |
| 17 | 3. 13 | 8. 7 | 10.58 | 10.56 | 7. 54 | 2. 38 | 13 |
| 18 | 3. 24 | 8. 15 | 11. 1 | 10.52 | 7. 45 | 2. 26 | 12 |
| 19 | 3. 35 | 8. 23 | 11. 3 | 10.49 | 7. 36 | 2. 14 | 11 |
| 20 | 3. 46 | 8. 31 | 11. 6 | 10.45 | 7. 27 | 2. 2 | 10 |
| 21 | 3. 57 | 8. 32 | 11. 8 | 10.41 | 7. 18 | 1. 50 | 9 |
| 22 | 4. 8 | 8. 46 | 11.10 | 10.37 | 7. 9 | 1. 38 | 8 |
| 23 | 4. 18 | 8. 54 | 11.12 | 10.33 | 7. 0 | 1. 26 | 7 |
| 24 | 4. 29 | 9. 1 | 11.14 | 10.29 | 6. 50 | 1. 14 | 6 |
| 25 | 4. 40 | 9. 8 | 11.16 | 10.24 | 6. 40 | 1. 1 | 5 |
| 26 | 4. 50 | 9. 15 | 11.17 | 10.19 | 6. 30 | 0. 49 | 4 |
| 27 | 5. 0 | 9. 21 | 11.18 | 10.14 | 6. 20 | 0. 37 | 3 |
| 28 | 5. 11 | 9. 28 | 11.19 | 10. 9 | 6. 9 | 0. 25 | 2 |
| 29 | 5. 21 | 9. 34 | 11.20 | 10. 4 | 5. 59 | 0. 13 | 1 |
| 30 | 5. 31 | 9. 40 | 11.20 | 9.58 | 5. 49 | 0. 0 | 0 |
| 0 | – | – | – | – | – | – | 0 |
|  | 11 | 10 | 9 | 8 | 7 | 6 |  |

### II. For the Long. of the Moon.

Argum. II.
Double Diſt. ☽ a ☉ + Argum. I.

| ° | 0<br>6<br>+ | 1<br>7<br>+ | 2<br>8<br>+ | ° |
|---|---|---|---|---|
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0. 27 | 0. 47 | 30 |
| 1 | 0. 1 | 0. 28 | 0. 47 | 29 |
| 2 | 0. 2 | 0. 29 | 0. 48 | 28 |
| 3 | 0. 3 | 0. 29 | 0. 48 | 27 |
| 4 | 0. 4 | 0. 30 | 0. 49 | 26 |
| 5 | 0. 5 | 0. 31 | 0. 49 | 25 |
| 6 | 0. 6 | 0. 31 | 0. 50 | 24 |
| 7 | 0. 7 | 0. 32 | 0. 50 | 23 |
| 8 | 0. 8 | 0. 33 | 0. 50 | 22 |
| 9 | 0. 9 | 0. 34 | 0. 51 | 21 |
| 10 | 0. 10 | 0. 34 | 0. 51 | 20 |
| 11 | 0. 11 | 0. 35 | 0. 51 | 19 |
| 12 | 0. 12 | 0. 36 | 0. 52 | 18 |
| 13 | 0. 13 | 0. 37 | 0. 52 | 17 |
| 14 | 0. 13 | 0. 37 | 0. 52 | 16 |
| 15 | 0. 14 | 0. 38 | 0. 52 | 15 |
| 16 | 0. 15 | 0. 39 | 0. 52 | 14 |
| 17 | 0. 16 | 0. 39 | 0. 53 | 13 |
| 18 | 0. 17 | 0. 40 | 0. 53 | 12 |
| 19 | 0. 18 | 0. 41 | 0. 53 | 11 |
| 20 | 0. 19 | 0. 41 | 0. 53 | 10 |
| 21 | 0. 19 | 0. 42 | 0. 53 | 9 |
| 22 | 0. 20 | 0. 42 | 0. 53 | 8 |
| 23 | 0. 21 | 0. 43 | 0. 53 | 7 |
| 24 | 0. 22 | 0. 44 | 0. 54 | 6 |
| 25 | 0. 23 | 0. 44 | 0. 54 | 5 |
| 26 | 0. 23 | 0. 45 | 0. 54 | 4 |
| 27 | 0. 24 | 0. 45 | 0. 54 | 3 |
| 28 | 0. 25 | 0. 46 | 0. 54 | 2 |
| 29 | 0. 26 | 0. 46 | 0. 54 | 1 |
| 30 | 0. 27 | 0 47 | 0. 54 | 0 |
| 0 | 11<br>+ | 10<br>+ | 9<br>+ | 0 |
|  | 5 | 4 | 3 |  |

### III. For Longitude of the ☽

Argum. III.
Double Diſt. ☽ *a* ☉—Arg. I.

|  | 0<br>− | 1<br>− | 2<br>− |  |
|---|---|---|---|---|
|  | 6<br>+ | 7<br>+ | 8<br>+ |  |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0. 31 | 0. 54 | 30 |
| 1 | 0. 1 | 0. 32 | 0. 54 | 29 |
| 2 | 0. 2 | 0. 33 | 0. 55 | 28 |
| 3 | 0. 3 | 0. 34 | 0. 55 | 27 |
| 4 | 0. 4 | 0. 35 | 0. 56 | 26 |
| 5 | 0. 6 | 0. 36 | 0. 56 | 25 |
| 6 | 0. 7 | 0. 37 | 0. 56 | 24 |
| 7 | 0. 8 | 0. 38 | 0. 57 | 23 |
| 8 | 0. 9 | 0. 38 | 0. 57 | 22 |
| 9 | 0. 10 | 0. 39 | 0. 58 | 21 |
| 10 | 0. 11 | 0. 40 | 0. 58 | 20 |
| 11 | 0. 12 | 0. 41 | 0. 58 | 19 |
| 12 | 0. 13 | 0. 42 | 0. 59 | 18 |
| 13 | 0. 14 | 0. 42 | 0. 59 | 17 |
| 14 | 0. 15 | 0. 43 | 1. 0 | 16 |
| 15 | 0. 16 | 0. 44 | 1. 0 | 15 |
| 16 | 0. 17 | 0. 45 | 1. 0 | 14 |
| 17 | 0. 18 | 0. 45 | 1. 0 | 13 |
| 18 | 0. 19 | 0. 46 | 1. 1 | 12 |
| 19 | 0. 20 | 0. 47 | 1. 1 | 11 |
| 20 | 0. 21 | 0. 48 | 1. 1 | 10 |
| 21 | 0. 22 | 0. 48 | 1. 1 | 9 |
| 22 | 0. 23 | 0. 49 | 1. 1 | 8 |
| 23 | 0. 24 | 0. 50 | 1. 1 | 7 |
| 24 | 0. 25 | 0. 50 | 1. 2 | 6 |
| 25 | 0. 26 | 0. 51 | 1. 2 | 5 |
| 26 | 0. 27 | 0. 51 | 1. 2 | 4 |
| 27 | 0. 28 | 0. 52 | 1. 2 | 3 |
| 28 | 0. 29 | 0. 52 | 1. 2 | 2 |
| 29 | 0. 30 | 0. 53 | 1. 2 | 1 |
| 30 | 0. 31 | 0. 54 | 1. 2 | 0 |
| 0 | + | + | + | 0 |
|  | 11 | 10 | 9 |  |
|  | − | − | − |  |
|  | 5 | 4 | 3 |  |

### IV. For Longitude of the ☽

Argum. IV.
Arg. II.—Mean Anomaly ☽

|  | 0<br>+ | 1<br>+ | 2<br>+ |  |
|---|---|---|---|---|
|  | 6<br>− | 7<br>− | 8<br>− |  |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0. 54 | 1. 34 | 30 |
| 1 | 0. 2 | 0. 56 | 1. 35 | 29 |
| 2 | 0. 4 | 0. 57 | 1. 36 | 28 |
| 3 | 0. 6 | 0. 59 | 1. 37 | 27 |
| 4 | 0. 8 | 1. 0 | 1. 38 | 26 |
| 5 | 0. 10 | 1. 2 | 1. 39 | 25 |
| 6 | 0. 12 | 1. 3 | 1. 39 | 24 |
| 7 | 0. 13 | 1. 5 | 1. 40 | 23 |
| 8 | 0. 15 | 1. 6 | 1. 41 | 22 |
| 9 | 0. 17 | 1. 8 | 1. 41 | 21 |
| 10 | 0. 19 | 1. 9 | 1. 42 | 20 |
| 11 | 0. 21 | 1. 10 | 1. 42 | 19 |
| 12 | 0. 23 | 1. 12 | 1. 43 | 18 |
| 13 | 0. 24 | 1. 13 | 1. 44 | 17 |
| 14 | 0. 26 | 1. 15 | 1. 44 | 16 |
| 15 | 0. 28 | 1. 16 | 1. 45 | 15 |
| 16 | 0. 30 | 1. 18 | 1. 45 | 14 |
| 17 | 0. 32 | 1. 19 | 1. 46 | 13 |
| 18 | 0. 33 | 1. 20 | 1. 46 | 12 |
| 19 | 0. 35 | 1. 22 | 1. 46 | 11 |
| 20 | 0. 37 | 1. 23 | 1. 47 | 10 |
| 21 | 0. 39 | 1. 24 | 1. 47 | 9 |
| 22 | 0. 41 | 1. 26 | 1. 47 | 8 |
| 23 | 0. 42 | 1. 27 | 1. 47 | 7 |
| 24 | 0. 44 | 1. 28 | 1. 47 | 6 |
| 25 | 0. 46 | 1. 29 | 1. 48 | 5 |
| 26 | 0. 48 | 1. 30 | 1. 48 | 4 |
| 27 | 0. 49 | 1. 31 | 1. 48 | 3 |
| 28 | 0. 51 | 1. 32 | 1. 48 | 2 |
| 29 | 0. 52 | 1. 33 | 1. 48 | 1 |
| 30 | 0. 54 | 1. 34 | 1. 48 | 0 |
| 0 | − | − | − | 0 |
|  | 11 | 10 | 9 |  |
|  | − | + | + |  |
|  | 5 | 4 | 3 |  |

### V. For Longitude of the ☽

Argum. V.
Arg. III.—Mean Anomaly ☽

|  | 0<br>+ | 1<br>+ | 2<br>+ |  |
|---|---|---|---|---|
|  | 6<br>− | 7<br>− | 8<br>− |  |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0. 36 | 1. 2 | 30 |
| 1 | 0. 1 | 0. 37 | 1. 3 | 29 |
| 2 | 0. 2 | 0. 38 | 1. 3 | 28 |
| 3 | 0. 4 | 0. 39 | 1. 4 | 27 |
| 4 | 0. 5 | 0. 40 | 1. 4 | 26 |
| 5 | 0. 6 | 0. 41 | 1. 5 | 25 |
| 6 | 0. 8 | 0. 42 | 1. 5 | 24 |
| 7 | 0. 9 | 0. 43 | 1. 6 | 23 |
| 8 | 0. 10 | 0. 44 | 1. 6 | 22 |
| 9 | 0. 12 | 0. 45 | 1. 7 | 21 |
| 10 | 0. 13 | 0. 46 | 1. 7 | 20 |
| 11 | 0. 14 | 0. 47 | 1. 8 | 19 |
| 12 | 0. 16 | 0. 48 | 1. 8 | 18 |
| 13 | 0. 17 | 0. 49 | 1. 9 | 17 |
| 14 | 0. 18 | 0. 50 | 1. 9 | 16 |
| 15 | 0. 19 | 0. 51 | 1. 10 | 15 |
| 16 | 0. 20 | 0. 52 | 1. 10 | 14 |
| 17 | 0. 22 | 0. 52 | 1. 10 | 13 |
| 18 | 0. 23 | 0. 53 | 1. 11 | 12 |
| 19 | 0. 24 | 0. 54 | 1. 11 | 11 |
| 20 | 0. 25 | 0. 55 | 1. 11 | 10 |
| 21 | 0. 26 | 0. 56 | 1. 11 | 9 |
| 22 | 0. 28 | 0. 56 | 1. 11 | 8 |
| 23 | 0. 29 | 0. 57 | 1. 11 | 7 |
| 24 | 0. 30 | 0. 58 | 1. 12 | 6 |
| 25 | 0. 31 | 0. 59 | 1. 12 | 5 |
| 26 | 0. 32 | 0. 59 | 1. 12 | 4 |
| 27 | 0. 33 | 1. 0 | 1. 12 | 3 |
| 28 | 0. 34 | 1. 1 | 1. 12 | 2 |
| 29 | 0. 35 | 1. 1 | 1. 12 | 1 |
| 30 | 0. 36 | 1. 2 | 1. 12 | 0 |
| 0 | − | − | − | 0 |
|  | 11 | 10 | 9 |  |
|  | + | + | + |  |
|  | 5 | 4 | 3 |  |

VI. For Longitude of ☽

Argum. VI.
Double Dist. ☽ a ☉ + Mean Anomaly ☽

| | 0<br>+ | 1<br>+ | 2<br>+ | |
|---|---|---|---|---|
| | 6<br>— | 7<br>— | 8<br>— | |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0. 45 | 1. 18 | 30 |
| 1 | 0. 2 | 0. 46 | 1. 19 | 29 |
| 2 | 0. 3 | 0. 48 | 1. 19 | 28 |
| 3 | 0. 5 | 0. 49 | 1. 20 | 27 |
| 4 | 0. 6 | 0. 51 | 1. 20 | 26 |
| 5 | 0. 8 | 0. 52 | 1. 21 | 25 |
| 6 | 0. 9 | 0. 53 | 1 22 | 24 |
| 7 | 0. 11 | 0. 55 | 1. 22 | 23 |
| 8 | 0. 13 | 0. 56 | 1. 23 | 22 |
| 9 | 0. 14 | 0. 57 | 1. 23 | 21 |
| 10 | 0. 16 | 0. 58 | 1. 24 | 20 |
| 11 | 0. 17 | 0. 59 | 1. 25 | 19 |
| 12 | 0. 19 | 1. 1 | 1. 25 | 18 |
| 13 | 0. 20 | 1. 2 | 1. 26 | 17 |
| 14 | 0. 22 | 1. 3 | 1. 26 | 16 |
| 15 | 0. 23 | 1. 4 | 1. 27 | 15 |
| 16 | 0. 25 | 1. 5 | 1. 27 | 14 |
| 17 | 0. 26 | 1. 6 | 1. 28 | 13 |
| 18 | 0. 28 | 1. 7 | 1. 28 | 12 |
| 19 | 0. 29 | 1. 8 | 1. 28 | 11 |
| 20 | 0. 31 | 1. 9 | 1. 29 | 10 |
| 21 | 0. 32 | 1. 10 | 1. 29 | 9 |
| 22 | 0. 34 | 1. 11 | 1. 29 | 8 |
| 23 | 0. 35 | 1. 12 | 1. 29 | 7 |
| 24 | 0. 37 | 1. 13 | 1. 29 | 6 |
| 25 | 0. 38 | 1. 14 | 1. 30 | 5 |
| 26 | 0. 39 | 1. 15 | 1. 30 | 4 |
| 27 | 0. 41 | 1. 16 | 1. 30 | 3 |
| 28 | 0. 42 | 1. 16 | 1. 30 | 2 |
| 29 | 0. 44 | 1. 17 | 1. 30 | 1 |
| 30 | 0. 45 | 1. 18 | 1. 30 | 0 |
| 0 | — | — | — | 0 |
| | 11 | 10 | 9 | |
| | +<br>5 | +<br>4 | +<br>3 | |

VII. For Longitude of ☽

Argum, VII.
Double Dist. ☽ a ☊ — Mean Anomaly ☽

| | 0<br>+ | 1<br>+ | 2<br>+ | |
|---|---|---|---|---|
| | 6<br>— | 7<br>— | 8<br>— | |
| ° | ′ ″ | ′ ″ | ′ ′ | ° |
| 0 | 0. 0 | 0. 29 | 0. 50 | 30 |
| 1 | 0. 1 | 0. 30 | 0. 50 | 29 |
| 2 | 0. 2 | 0. 31 | 0. 51 | 28 |
| 3 | 0. 3 | 0. 31 | 0. 51 | 27 |
| 4 | 0. 4 | 0. 32 | 0. 52 | 26 |
| 5 | 0. 5 | 0. 33 | 0. 52 | 25 |
| 6 | 0. 6 | 0. 34 | 0. 53 | 24 |
| 7 | 0. 7 | 0. 35 | 0. 53 | 23 |
| 8 | 0. 8 | 0. 35 | 0. 54 | 22 |
| 9 | 0. 9 | 0. 36 | 0. 54 | 21 |
| 10 | 0. 10 | 0. 37 | 0. 54 | 20 |
| 11 | 0. 11 | 0. 38 | 0. 55 | 19 |
| 12 | 0. 12 | 0. 38 | 0. 55 | 18 |
| 13 | 0. 13 | 0. 39 | 0. 55 | 17 |
| 14 | 0. 14 | 0. 40 | 0. 56 | 16 |
| 15 | 0. 15 | 0. 41 | 0. 56 | 15 |
| 16 | 0. 16 | 0. 41 | 0. 56 | 14 |
| 17 | 0. 17 | 0. 42 | 0. 56 | 13 |
| 18 | 0. 18 | 0. 43 | 0. 57 | 12 |
| 19 | 0. 19 | 0. 43 | 0. 57 | 11 |
| 20 | 0. 20 | 0. 44 | 0. 57 | 10 |
| 21 | 0. 21 | 0. 45 | 0. 57 | 9 |
| 22 | 0. 22 | 0. 45 | 0. 57 | 8 |
| 23 | 0. 23 | 0. 46 | 0. 58 | 7 |
| 24 | 0. 24 | 0. 46 | 0. 58 | 6 |
| 25 | 0. 25 | 0. 47 | 0. 58 | 5 |
| 26 | 0. 26 | 0. 47 | 0. 58 | 4 |
| 27 | 0. 27 | 0. 48 | 0. 58 | 3 |
| 28 | 0. 27 | 0. 49 | 0. 58 | 2 |
| 29 | 0. 28 | 0. 49 | 0. 58 | 1 |
| 30 | 0. 29 | 0. 50 | 0. 58 | 0 |
| 0 | — | — | — | 0 |
| | 11 | 10 | 9 | |
| | +<br>5 | +<br>4 | +<br>3 | |

VIII. For Longitude of ☽

Argum. VIII.
Mean Anomaly ☽ — Arg. I.

| | 0<br>+ | 1<br>+ | 2<br>+ | |
|---|---|---|---|---|
| | 6<br>— | 7<br>— | 8<br>— | |
| ° | ′ ″ | ′ ′ | ′ ″ | ° |
| 0 | 0. 0 | 0. 20 | 0. 35 | 30 |
| 1 | 0. 1 | 0. 20 | 0. 35 | 29 |
| 2 | 0. 2 | 0. 21 | 0. 36 | 28 |
| 3 | 0. 2 | 0. 21 | 0. 36 | 27 |
| 4 | 0. 3 | 0. 22 | 0. 36 | 26 |
| 5 | 0. 4 | 0. 23 | 0. 37 | 25 |
| 6 | 0. 4 | 0. 23 | 0. 37 | 24 |
| 7 | 0. 5 | 0. 24 | 0. 37 | 23 |
| 8 | 0. 6 | 0. 24 | 0. 37 | 22 |
| 9 | 0. 6 | 0. 25 | 0. 38 | 21 |
| 10 | 0. 7 | 0. 26 | 0. 38 | 20 |
| 11 | 0. 7 | 0. 26 | 0. 38 | 19 |
| 12 | 0. 8 | 0. 27 | 0. 38 | 18 |
| 13 | 0. 9 | 0. 27 | 0. 38 | 17 |
| 14 | 0. 9 | 0. 28 | 0. 38 | 16 |
| 15 | 0. 10 | 0. 28 | 0. 39 | 15 |
| 16 | 0. 11 | 0. 29 | 0. 39 | 14 |
| 17 | 0. 11 | 0. 29 | 0. 39 | 13 |
| 18 | 0. 12 | 0. 30 | 0. 39 | 12 |
| 19 | 0. 13 | 0. 30 | 0. 39 | 11 |
| 20 | 0. 13 | 0. 31 | 0. 39 | 10 |
| 21 | 0. 14 | 0. 31 | 0. 39 | 9 |
| 22 | 0. 15 | 0. 32 | 0. 40 | 8 |
| 23 | 0. 15 | 0. 32 | 0. 40 | 7 |
| 24 | 0. 16 | 0. 33 | 0. 40 | 6 |
| 25 | 0. 17 | 0. 33 | 0. 40 | 5 |
| 26 | 0. 17 | 0. 34 | 0. 40 | 4 |
| 27 | 0. 18 | 0. 34 | 0. 40 | 3 |
| 28 | 0. 19 | 0. 34 | 0. 40 | 2 |
| 29 | 0. 19 | 0. 35 | 0. 40 | 1 |
| 30 | 0. 20 | 0. 35 | 0. 40 | 0 |
| 0 | — | — | — | 0 |
| | 11 | 10 | 9 | |
| | +<br>5 | +<br>4 | + | |

### IX. For Longitude of ☽

Argum. IX.
Long ☊—true Longit. ☉

| | 0 | 1 | 2 | |
|---|---|---|---|---|
| | + | + | + | |
| | 6 | 7 | 8 | |
| | + | + | + | |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 0.41 | 0.41 | 30 |
| 1 | 0. 2 | 0.41 | 0.40 | 29 |
| 2 | 0. 3 | 0.42 | 0.39 | 28 |
| 3 | 0. 5 | 0.43 | 0.38 | 27 |
| 4 | 0. 6 | 0.43 | 0.37 | 26 |
| 5 | 0. 8 | 0.44 | 0.36 | 25 |
| 6 | 0.10 | 0.44 | 0.35 | 24 |
| 7 | 0.11 | 0.45 | 0.34 | 23 |
| 8 | 0.13 | 0.45 | 0.32 | 22 |
| 9 | 0.14 | 0.46 | 0.31 | 21 |
| 10 | 0.16 | 0.46 | 0.30 | 20 |
| 11 | 0.17 | 0.46 | 0.29 | 19 |
| 12 | 0.19 | 0.47 | 0.27 | 18 |
| 13 | 0.20 | 0.47 | 0.26 | 17 |
| 14 | 0.22 | 0.47 | 0.25 | 16 |
| 15 | 0.23 | 0.47 | 0.23 | 15 |
| 16 | 0.25 | 0.47 | 0.22 | 14 |
| 17 | 0.26 | 0.47 | 0.20 | 13 |
| 18 | 0.27 | 0.47 | 0.19 | 12 |
| 19 | 0.29 | 0.46 | 0.17 | 11 |
| 20 | 0.30 | 0.46 | 0.16 | 10 |
| 21 | 0.31 | 0.46 | 0.14 | 9 |
| 22 | 0.32 | 0.45 | 0.13 | 8 |
| 23 | 0.34 | 0.45 | 0.11 | 7 |
| 24 | 0.35 | 0.44 | 0.10 | 6 |
| 25 | 0.36 | 0.44 | 0. 8 | 5 |
| 26 | 0.37 | 0.43 | 0. 6 | 4 |
| 27 | 0.38 | 0.43 | 0. 5 | 3 |
| 28 | 0.39 | 0.42 | 0. 3 | 2 |
| 29 | 0.40 | 0.41 | 0. 2 | 1 |
| 30 | 0.41 | 0.41 | 0. 0 | 0 |
| 0 | − | − | − | 0 |
| | 11 | 10 | 9 | |
| | − | − | − | |
| | 5 | 4 | 3 | |

### X. For Longtitude of ☽

Argum. X.
Dist. ☽ à ☉—Mean Anomaly ☽

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| | + | + | + | ± | − | − | |
| ° | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 3.11 | 3.22 | 0.29 | 2.32 | 2.42 | 30 |
| 1 | 0. 8 | 3.15 | 3.19 | 0.22 | 2.35 | 2.39 | 29 |
| 2 | 0.15 | 3.19 | 3.15 | 0.15 | 2.39 | 2.36 | 28 |
| 3 | 0.23 | 3.22 | 3.11 | 0. 8 | 2.42 | 2.32 | 27 |
| 4 | 0.30 | 3.25 | 3. 7 | 0. 1 | 2.45 | 2.28 | 26 |
| 5 | 0.38 | 3.28 | 3. 3 | 0. 6 | 2.48 | 2.24 | 25 |
| 6 | 0.45 | 3.31 | 2.58 | 0.13 | 2.51 | 2.20 | 24 |
| 7 | 0.53 | 3.33 | 2.53 | 0.20 | 2.53 | 2.15 | 23 |
| 8 | 1. 0 | 3.36 | 2.48 | 0.27 | 2.55 | 2.11 | 22 |
| 9 | 1. 8 | 3.38 | 2.43 | 0.34 | 2.57 | 2. 6 | 21 |
| 10 | 1.15 | 3.40 | 2.38 | 0.41 | 2.59 | 2. 1 | 20 |
| 11 | 1.22 | 3.42 | 2.32 | 0.48 | 3. 0 | 1.56 | 19 |
| 12 | 1.29 | 3.43 | 2.27 | 0.54 | 3. 1 | 1.51 | 18 |
| 13 | 1.36 | 3.44 | 2.21 | 1. 1 | 3. 2 | 1.46 | 17 |
| 14 | 1.43 | 3.44 | 2.16 | 1. 8 | 3. 3 | 1.40 | 16 |
| 15 | 1.50 | 3.45 | 2.10 | 1.14 | 3. 4 | 1.35 | 15 |
| 16 | 1.56 | 3.45 | 2. 4 | 1.20 | 3. 4 | 1.29 | 14 |
| 17 | 2. 3 | 3.44 | 1.58 | 1.26 | 3. 3 | 1.23 | 13 |
| 18 | 2. 9 | 3.44 | 1.51 | 1.32 | 3. 3 | 1.17 | 12 |
| 19 | 2.15 | 3.43 | 1.45 | 1.38 | 3. 2 | 1.11 | 11 |
| 20 | 2.21 | 3.43 | 1.38 | 1.44 | 3. 2 | 1. 5 | 10 |
| 21 | 2.26 | 3.42 | 1.32 | 1.49 | 3. 1 | 0.59 | 9 |
| 22 | 2.32 | 3.41 | 1.25 | 1.55 | 3. 0 | 0.53 | 8 |
| 23 | 2.37 | 3.39 | 1.18 | 2. 0 | 2.59 | 0.46 | 7 |
| 24 | 2.43 | 3.37 | 1.11 | 2. 5 | 2.57 | 0.40 | 6 |
| 25 | 2.48 | 3.35 | 1. 4 | 2.10 | 2.55 | 0.33 | 5 |
| 26 | 2.53 | 3.33 | 0.57 | 2.15 | 2.53 | 0.27 | 4 |
| 27 | 2.58 | 3.30 | 0.50 | 2.19 | 2.50 | 0.20 | 3 |
| 28 | 3. 2 | 3.28 | 0.43 | 2.24 | 2.48 | 0.14 | 2 |
| 29 | 3. 7 | 3.25 | 0.36 | 2.28 | 2.45 | 0. 7 | 1 |
| 30 | 3.11 | 3.22 | 0.29 | 2.32 | 2.42 | 0. 0 | 0 |
| 0 | − | − | − | ∓ | + | + | 0 |
| | 11 | 10 | 9 | 8 | 7 | 6 | |

## X. For Longitude of ☽. Equation of the Center.

Argum. XI.
Anomaly of the Moon corrected.

|  | 0 |  | 1 |  | 2 |  |  |
|---|---|---|---|---|---|---|---|
|  | — | *Diff.* | — | *Diff.* | — | *Diff.* |  |
| ° | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° |
| 0 | 0. 0. 0. | 6. 11 | 2. 58. 33 | 5. 28 | 5. 16. 28 | 3. 27 | 30 |
| 1 | 0. 6. 11 | 6. 11 | 3. 4. 1 | 5. 25 | 5. 19. 55 | 3. 22 | 29 |
| 2 | 0. 12. 22 | 6. 10 | 3. 9. 26 | 5. 22 | 5. 23. 17 | 3. 17 | 28 |
| 3 | 0. 18. 32 | 6. 10 | 3. 14. 48 | 5. 19 | 5. 26. 34 | 3. 12 | 27 |
| 4 | 0. 24. 42 | 6. 10 | 3. 20. 7 | 5. 17 | 5. 29. 46 | 3. 7 | 26 |
| 5 | 0. 30. 52 | 6. 10 | 3. 25. 24 | 5. 14 | 5. 32. 53 | 3. 1 | 25 |
| 6 | 0. 37. 2 | 6. 9 | 3. 30. 38 | 5. 10 | 5. 35. 54 | 2. 55 | 24 |
| 7 | 0. 43. 11 | 6. 8 | 3. 35. 48 | 5. 7 | 5. 38. 49 | 2. 49 | 23 |
| 8 | 0. 49. 19 | 6. 8 | 3. 40. 55 | 5. 3 | 5. 41. 38 | 2. 43 | 22 |
| 9 | 0. 55. 27 | 6. 7 | 3. 45. 58 | 4. 59 | 5. 44. 21 | 2. 37 | 21 |
| 10 | 1. 1. 34 | 6. 6 | 3. 50. 57 | 4. 56 | 5. 46. 58 | 2. 31 | 20 |
| 11 | 1. 7. 40 | 6. 5 | 3. 55. 53 | 4. 52 | 5. 49. 29 | 2. 26 | 19 |
| 12 | 1. 13. 45 | 6. 3 | 4. 0. 45 | 4. 49 | 5. 51. 55 | 2. 20 | 18 |
| 13 | 1. 19. 48 | 6. 2 | 4. 5. 34 | 4. 45 | 5. 54. 15 | 2. 14 | 17 |
| 14 | 1. 25. 50 | 6. 2 | 4. 10. 19 | 4. 41 | 5. 56. 29 | 2. 8 | 16 |
| 15 | 1. 31. 52 | 6. 0 | 4. 15. 0 | 4. 37 | 5. 58. 37 | 2. 2 | 15 |
| 16 | 1. 37. 52 | 5. 58 | 4. 19. 37 | 4. 33 | 6. 0. 39 | 1. 55 | 14 |
| 17 | 1. 43. 50 | 5. 57 | 4. 24. 10 | 4. 28 | 6. 2. 34 | 1. 49 | 13 |
| 18 | 1. 49. 47 | 5. 55 | 4. 28. 38 | 4. 24 | 6. 4. 23 | 1. 43 | 12 |
| 19 | 1. 55. 42 | 5. 53 | 4. 33. 2 | 4. 20 | 6. 6. 6 | 1. 37 | 11 |
| 20 | 2. 1. 35 | 5. 51 | 4. 37. 22 | 4. 16 | 6. 7. 42 | 1. 30 | 10 |
| 21 | 2. 7. 26 | 5. 49 | 4. 41. 38 | 4. 11 | 6. 9. 13 | 1. 24 | 9 |
| 22 | 2. 13. 15 | 5. 47 | 4. 45. 49 | 4. 6 | 6. 10. 37 | 1. 17 | 8 |
| 23 | 2. 19. 2 | 5. 46 | 4. 49. 55 | 4. 2 | 6. 11. 54 | 1. 11 | 7 |
| 24 | 2. 24. 48 | 5. 44 | 4. 53. 57 | 3. 58 | 6. 13. 5 | 1. 5 | 6 |
| 25 | 2. 30. 32 | 5. 42 | 4. 57. 55 | 3. 53 | 6. 14. 10 | 0. 58 | 5 |
| 26 | 2. 36. 14 | 5. 39 | 5. 1. 48 | 3. 48 | 6. 15. 8 | 0. 51 | 4 |
| 27 | 2. 41. 53 | 5. 36 | 5. 5. 36 | 3. 43 | 6. 15. 59 | 0. 44 | 3 |
| 28 | 2. 47. 29 | 5. 33 | 5. 9. 19 | 3. 37 | 6. 16. 43 | 0. 37 | 2 |
| 29 | 2. 53. 2 | 5. 31 | 5. 12. 56 | 3. 32 | 6. 17. 20 | 0. 30 | 1 |
| 30 | 2. 58. 33 |  | 5. 16. 28 |  | 6. 17. 50 |  | 0 |
| 0 | + |  | + |  | + |  | 0 |
|  | 11 |  | 10 |  | 9 |  |  |

## XI. For Longitude of ☽. Equation of the Center.

Argum. XI.
Anomaly of the Moon corrected.

|  | 3 |  | 4 |  | 5 |  |  |
|---|---|---|---|---|---|---|---|
|  | — | *Diff.* | — | *Diff.* | — | *Diff.* |  |
| ° | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° |
| 0 | 6. 17. 50 | 0. 24 | 5. 39. 0 | 3. 7 | 3. 21. 4 | 6. 0 | 30 |
| 1 | 6. 18. 14 | 0. 17 | 5. 35. 53 | 3. 13 | 3. 15. 4 | 6. 3 | 29 |
| 2 | 6. 18. 31 | 0. 10 | 5. 32. 40 | 3. 20 | 3. 9. 1 | 6. 7 | 28 |
| 3 | 6. 18. 41 | 0. 3 | 5. 29. 20 | 3. 27 | 3. 2. 54 | 6. 11 | 27 |
| 4 | 6. 18. 44 | 0. 4 | 5. 25. 53 | 3. 32 | 2. 56. 43 | 6. 15 | 26 |
| 5 | 6. 18. 40 | 0. 11 | 5. 22. 21 | 3. 39 | 2. 50. 28 | 6. 19 | 25 |
| 6 | 6. 18. 29 | 0. 18 | 5. 18. 42 | 3. 46 | 2. 44. 9 | 6. 22 | 24 |
| 7 | 6. 18. 11 | 0. 25 | 5. 14. 56 | 3. 52 | 2. 37. 47 | 6. 26 | 23 |
| 8 | 6. 17. 46 | 0. 32 | 5. 11. 4 | 3. 59 | 2. 31. 21 | 6. 30 | 22 |
| 9 | 6. 17. 14 | 0. 38 | 5. 7. 5 | 4. 6 | 2. 24. 51 | 6. 33 | 21 |
| 10 | 6. 16. 36 | 0. 46 | 5. 2. 59 | 4. 12 | 2. 18. 18 | 6. 36 | 20 |
| 11 | 6. 15. 50 | 0. 53 | 4. 58. 47 | 4. 18 | 2. 11. 42 | 6. 38 | 19 |
| 12 | 6. 14. 57 | 1. 0 | 4. 54. 29 | 4. 24 | 2. 5. 4 | 6. 41 | 18 |
| 13 | 6. 13. 57 | 1. 7 | 4. 50. 5 | 4. 29 | 1. 58. 23 | 6. 44 | 17 |
| 14 | 6. 12. 50 | 1. 14 | 4. 45. 36 | 4. 35 | 1. 51. 39 | 6. 47 | 16 |
| 15 | 6. 11. 36 | 1. 21 | 4. 41. 1 | 4. 41 | 1. 44. 52 | 6. 49 | 15 |
| 16 | 6. 10. 15 | 1. 28 | 4. 36. 20 | 4. 47 | 1. 38. 3 | 6. 51 | 14 |
| 17 | 6. 8. 47 | 1. 35 | 4. 31. 33 | 4. 54 | 1. 31. 12 | 6. 54 | 13 |
| 18 | 6. 7. 12 | 1. 43 | 4. 26. 39 | 4. 59 | 1. 24. 18 | 6. 55 | 12 |
| 19 | 6. 5. 29 | 1. 50 | 4. 21. 40 | 5. 6 | 1. 17. 23 | 6. 56 | 11 |
| 20 | 6. 3. 39 | 1. 57 | 4. 16. 34 | 5. 11 | 1. 10. 27 | 6. 58 | 10 |
| 21 | 6. 1. 42 | 2. 4 | 4. 11. 23 | 5. 16 | 1. 3. 29 | 6. 59 | 9 |
| 22 | 5. 59. 38 | 2. 10 | 4. 6. 7 | 5. 21 | 0. 56. 30 | 7. 1 | 8 |
| 23 | 5. 57. 28 | 2. 17 | 4. 0. 46 | 5. 25 | 0. 49. 29 | 7. 2 | 7 |
| 24 | 5. 55. 11 | 2. 24 | 3. 55. 21 | 5. 30 | 0. 42. 27 | 7. 4 | 6 |
| 25 | 5. 52. 47 | 2. 31 | 3. 49. 51 | 5. 35 | 0. 35. 23 | 7. 4 | 5 |
| 26 | 5. 50. 16 | 2. 38 | 3. 44. 16 | 5. 40 | 0. 28. 19 | 7. 4 | 4 |
| 27 | 5. 47. 38 | 2. 45 | 3. 38. 36 | 5. 46 | 0. 21. 15 | 7. 5 | 3 |
| 28 | 5. 44. 53 | 2. 53 | 3. 32. 50 | 5. 50 | 0. 14. 10 | 7. 5 | 2 |
| 29 | 5. 42. 0 | 3. 0 | 3. 27. 0 | 5. 56 | 0. 7. 5 | 7. 5 | 1 |
| 30 | 5. 39. 0 |  | 3. 21. 4 |  | 0. 0. 0 |  | 0 |
| ° | + |  | + |  | + |  | ° |
|  | 8 |  | 7 |  | 6 |  |  |

## XII. For Longitude of the Moon. Evection.

Argum. XII.
Double Dist. ☽ a ☉ corr.—Anom. ☽ corr.

| | 0 | | I | | 2 | | |
|---|---|---|---|---|---|---|---|
| | — | *Diff.* | — | *Diff.* | — | *Diff.* | |
| ° | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° |
| 0 | 0. 0. 0 | 1. 24 | 0. 39. 50 | 1. 12 | 1. 9. 22 | 0. 42 | 30 |
| 1 | 0. 1. 24 | 1. 23 | 0. 41. 2 | 1. 12 | 1. 10. 4 | 0. 41 | 29 |
| 2 | 0. 2. 47 | 1. 23 | 0. 42. 14 | 1. 11 | 1. 10. 45 | 0. 40 | 28 |
| 3 | 0. 4. 10 | 1. 23 | 0. 43. 25 | 1. 10 | 1. 11. 25 | 0. 39 | 27 |
| 4 | 0. 5. 33 | 1. 23 | 0. 44. 35 | 1. 9 | 1. 12. 4 | 0. 37 | 26 |
| 5 | 0. 6. 56 | 1. 23 | 0. 45. 44 | 1. 8 | 1. 12. 41 | 0. 36 | 25 |
| 6 | 0. 8. 19 | 1. 23 | 0. 46. 52 | 1. 7 | 1. 13. 17 | 0. 34 | 24 |
| 7 | 0. 9. 42 | 1. 23 | 0. 47. 59 | 1. 7 | 1. 13. 51 | 0. 33 | 23 |
| 8 | 0. 11. 5 | 1. 22 | 0. 49. 6 | 1. 6 | 1. 14. 24 | 0. 32 | 22 |
| 9 | 0. 12. 27 | 1. 22 | 0. 50. 12 | 1. 5 | 1. 14. 56 | 0. 31 | 21 |
| 10 | 0. 13. 49 | 1. 22 | 0. 51. 17 | 1. 4 | 1. 15. 27 | 0. 29 | 20 |
| 11 | 0. 15. 11 | 1. 22 | 0. 52. 21 | 1. 3 | 1. 15. 56 | 0. 28 | 19 |
| 12 | 0. 16. 33 | 1. 21 | 0. 53. 24 | 1. 2 | 1. 16. 24 | 0. 26 | 18 |
| 13 | 0. 17. 54 | 1. 21 | 0. 54. 26 | 1. 1 | 1. 16. 50 | 0. 25 | 17 |
| 14 | 0. 19. 15 | 1. 21 | 0. 55. 27 | 1. 1 | 1. 17. 15 | 0. 24 | 16 |
| 15 | 0. 20. 36 | 1. 20 | 0. 56. 28 | 1. 0 | 1. 17. 39 | 0. 22 | 15 |
| 16 | 0. 21. 56 | 1. 20 | 0. 57. 28 | 0. 58 | 1. 18. 1 | 0. 21 | 14 |
| 17 | 0. 23. 16 | 1. 19 | 0. 58. 26 | 0. 57 | 1. 18. 22 | 0. 19 | 13 |
| 18 | 0. 24. 35 | 1. 19 | 0. 59. 23 | 0. 56 | 1. 18. 41 | 0. 18 | 12 |
| 19 | 0. 25. 54 | 1. 19 | 1. 0. 19 | 0. 55 | 1. 18. 59 | 0. 17 | 11 |
| 20 | 0. 27. 13 | 1. 18 | 1. 1. 14 | 0. 54 | 1. 19. 16 | 0. 15 | 10 |
| 21 | 0. 28. 31 | 1. 18 | 1. 2. 8 | 0. 53 | 1. 19. 31 | 0. 14 | 9 |
| 22 | 0. 29. 49 | 1. 17 | 1. 3. 1 | 0. 52 | 1. 19. 45 | 0. 12 | 8 |
| 23 | 0. 31. 6 | 1. 17 | 1. 3. 53 | 0. 51 | 1. 19. 57 | 0. 11 | 7 |
| 24 | 0. 32. 23 | 1. 16 | 1. 4. 44 | 0. 49 | 1. 20. 8 | 0. 9 | 6 |
| 25 | 0. 33. 39 | 1. 15 | 1. 5. 33 | 0. 48 | 1. 20. 17 | 0. 8 | 5 |
| 26 | 0. 34. 54 | 1. 15 | 1. 6. 21 | 0. 47 | 1. 20. 25 | 0. 6 | 4 |
| 27 | 0. 36. 9 | 1. 14 | 1. 7. 8 | 0. 46 | 1. 20. 31 | 0. 5 | 3 |
| 28 | 0. 37. 23 | 1. 14 | 1. 7. 54 | 0. 45 | 1. 20. 36 | 0. 4 | 2 |
| 29 | 0. 38. 37 | 1. 13 | 1. 8. 39 | 0. 43 | 1. 20. 40 | 0. 2 | 1 |
| 30 | 0. 39. 50 | | 1. 9. 22 | | 1. 20. 42 | | 0 |
| 0 | + | | + | | + | | 0 |
| | 11 | | 10 | | 9 | | |

## XII. For Longitude of the Moon. Evection.

Argum. XII.
Double Dist. ☽ a ☉ corr.—Anom. ☽ corr.

| | 3 | | 4 | | 5 | | |
|---|---|---|---|---|---|---|---|
| | — | Diff. | — | Diff. | — | Diff. | |
| ° | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° ′ ″ | ′ ″ | ° |
| 0 | 1. 20. 42 | 0. 1 | 1. 10. 24 | 0. 42 | 0. 40. 52 | 1. 14 | 30 |
| 1 | 1. 20. 43 | 0. 1 | 1. 9. 42 | 0. 44 | 0. 39. 38 | 1. 15 | 29 |
| 2 | 1. 20. 42 | 0. 3 | 1. 8. 58 | 0. 45 | 0. 38. 23 | 1. 16 | 28 |
| 3 | 1. 20. 39 | 0. 4 | 1. 8. 13 | 0. 46 | 0. 37. 7 | 1. 17 | 27 |
| 4 | 1. 20. 35 | 0. 5 | 1. 7. 27 | 0. 47 | 0. 35. 50 | 1. 17 | 26 |
| 5 | 1. 20. 30 | 0. 7 | 1. 6. 40 | 0. 48 | 0. 34. 33 | 1. 18 | 25 |
| 6 | 1. 20. 23 | 0. 8 | 1. 5. 52 | 0. 50 | 0. 33. 15 | 1. 18 | 24 |
| 7 | 1. 20. 15 | 0. 10 | 1. 5. 2 | 0. 51 | 0. 31. 57 | 1. 19 | 23 |
| 8 | 1. 20. 5 | 0. 11 | 1. 4. 11 | 0. 53 | 0. 30. 38 | 1. 19 | 22 |
| 9 | 1. 19. 54 | 0. 13 | 1. 3. 18 | 0. 54 | 0. 29. 19 | 1. 20 | 21 |
| 10 | 1. 19. 41 | 0. 14 | 1. 2. 24 | 0. 55 | 0. 27. 59 | 1. 21 | 20 |
| 11 | 1. 19. 27 | 0. 16 | 1. 1. 29 | 0. 56 | 0. 26. 38 | 1. 21 | 19 |
| 12 | 1. 19. 11 | 0. 17 | 1. 0. 33 | 0. 57 | 0. 25. 17 | 1. 22 | 18 |
| 13 | 1. 18. 54 | 0. 19 | 0. 59. 36 | 0. 58 | 0. 23. 55 | 1. 22 | 17 |
| 14 | 1. 18. 35 | 0. 20 | 0. 58. 38 | 0. 59 | 0. 22. 33 | 1. 22 | 16 |
| 15 | 1. 18. 15 | 0. 22 | 0. 57. 39 | 1. 0 | 0. 21. 11 | 1. 23 | 15 |
| 16 | 1. 17. 53 | 0. 23 | 0. 56. 39 | 1. 1 | 0. 19. 48 | 1. 23 | 14 |
| 17 | 1. 17. 30 | 0. 24 | 0. 55. 38 | 1. 2 | 0. 18. 25 | 1. 24 | 13 |
| 18 | 1. 17. 6 | 0. 26 | 0. 54. 36 | 1. 4 | 0. 17. 1 | 1. 24 | 12 |
| 19 | 1. 16. 40 | 0. 27 | 0. 53. 32 | 1. 5 | 0. 15. 37 | 1. 24 | 11 |
| 20 | 1. 16. 13 | 0. 29 | 0. 52. 27 | 1. 6 | 0. 14. 13 | 1. 25 | 10 |
| 21 | 1. 15. 44 | 0. 30 | 0. 51. 21 | 1. 6 | 0. 12. 48 | 1. 25 | 9 |
| 22 | 1. 15. 14 | 0. 31 | 0. 50. 15 | 1. 7 | 0. 11. 23 | 1. 25 | 8 |
| 23 | 1. 14. 43 | 0. 33 | 0. 49. 8 | 1. 8 | 0. 9. 58 | 1. 25 | 7 |
| 24 | 1. 14. 10 | 0. 34 | 0. 48. 0 | 1. 9 | 0. 8. 33 | 1. 25 | 6 |
| 25 | 1. 13. 36 | 0. 36 | 0. 46. 51 | 1. 10 | 0. 7. 8 | 1. 25 | 5 |
| 26 | 1. 13. 0 | 0. 37 | 0. 45. 41 | 1. 11 | 0. 5. 43 | 1. 25 | 4 |
| 27 | 1. 12. 23 | 0. 38 | 0. 44. 30 | 1. 12 | 0. 4. 18 | 1. 26 | 3 |
| 28 | 1. 11. 45 | 0. 40 | 0. 43. 18 | 1. 13 | 0. 2. 52 | 1. 26 | 2 |
| 29 | 1. 11. 5 | 0. 41 | 0. 42. 5 | 1. 13 | 0. 1. 26 | 1. 26 | 1 |
| 30 | 1. 10. 24 | | 0. 40. 52 | | 0. 0. 0 | | 0 |
| ° | + | | + | | + | | ° |
| | 8 | | 7 | | 6 | | |

## XIII. For Longitude of the Moon. Variation.

Argum. XIII.
Longitude of ☽ Equated—true Longitude of ⊙

| | 0 | | 1 | | 2 | | 3 | | 4 | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | + | *Diff.* | + | *Diff.* | ± | *Diff.* | — | *Diff.* | — | *Diff.* | — | *Diff.* | |
| ° | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ′ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | | 34.17 | | 33. 2 | | 1.57 | | 36.21 | | 36. 8 | | 30 |
| 1 | 1.24 | 1.24 | 34.56 | 0.39 | 32.17 | 0.45 | 3.21 | 1.24 | 37. 1 | 0.40 | 35.23 | 0.45 | 29 |
| 2 | 2.48 | 1.24 | 35.32 | 0.36 | 31.30 | 0.47 | 4.44 | 1.23 | 37.39 | 0.38 | 34.36 | 0.47 | 28 |
| 3 | 4.11 | 1.23 | 36. 5 | 0.33 | 30.40 | 0.50 | 6. 7 | 1.23 | 38.14 | 0.35 | 33.46 | 0.50 | 27 |
| 4 | 5.34 | 1.23 | 36.35 | 0.30 | 29.47 | 0.53 | 7.29 | 1.22 | 38.47 | 0.33 | 32.54 | 0.52 | 26 |
| 5 | 6.57 | 1.23 | 37. 2 | 0.27 | 28.52 | 0.55 | 8.51 | 1.22 | 39.17 | 0.30 | 31.59 | 0.55 | 25 |
| 6 | 8.19 | 1.22 | 37.26 | 0.24 | 27.55 | 0.57 | 10.12 | 1.21 | 39.44 | 0.27 | 31. 2 | 0.57 | 24 |
| 7 | 9.40 | 1.21 | 37.48 | 0.22 | 26.56 | 0.59 | 11.33 | 1.21 | 40. 8 | 0.24 | 30. 3 | 0.59 | 23 |
| 8 | 11. 1 | 1.21 | 38. 7 | 0.19 | 25.56 | 1. 0 | 12.53 | 1.20 | 40.30 | 0.22 | 29. 1 | 1. 2 | 22 |
| 9 | 12.21 | 1.20 | 38.24 | 0.17 | 24.54 | 1. 2 | 14.13 | 1.20 | 40.49 | 0.19 | 27.57 | 1. 4 | 21 |
| 10 | 13.40 | 1.19 | 38.38 | 0.14 | 23.50 | 1. 4 | 15.32 | 1.19 | 41. 5 | 0.16 | 26.51 | 1. 6 | 20 |
| 11 | 14.58 | 1.18 | 38.49 | 0.11 | 22.44 | 1. 6 | 16.50 | 1.18 | 41.18 | 0.13 | 25.43 | 1. 8 | 19 |
| 12 | 16.15 | 1.17 | 38.57 | 0. 8 | 21.36 | 1. 8 | 18. 6 | 1.16 | 41.28 | 0.10 | 24.33 | 1.10 | 18 |
| 13 | 17.31 | 1.16 | 39. 2 | 0. 5 | 20.27 | 1. 9 | 19.21 | 1.15 | 41.35 | 0. 7 | 23.22 | 1.11 | 17 |
| 14 | 18.45 | 1.14 | 39. 3 | 0. 1 | 19.16 | 1.11 | 20.35 | 1.14 | 41.39 | 0. 4 | 22. 9 | 1.13 | 16 |
| 15 | 19.58 | 1.13 | 39. 1 | 0. 2 | 18. 3 | 1.13 | 21.48 | 1.13 | 41.41 | 0. 2 | 20.54 | 1.15 | 15 |
| 16 | 21. 9 | 1.11 | 38.56 | 0. 5 | 16.49 | 1.14 | 22.59 | 1.11 | 41.40 | 0. 1 | 19.38 | 1.16 | 14 |
| 17 | 22.18 | 1. 9 | 38.49 | 0. 7 | 15.34 | 1.15 | 24. 9 | 1.10 | 41.35 | 0. 5 | 18.20 | 1.18 | 13 |
| 18 | 23.25 | 1. 7 | 38.39 | 0.10 | 14.18 | 1.16 | 25.17 | 1. 8 | 41.27 | 0. 8 | 17. 1 | 1.19 | 12 |
| 19 | 24.31 | 1. 6 | 38.26 | 0.13 | 13. 1 | 1.17 | 26.23 | 1. 6 | 41.16 | 0.11 | 15.40 | 1.21 | 11 |
| 20 | 25.35 | 1. 4 | 38.11 | 0.15 | 11.42 | 1.19 | 27.23 | 1. 5 | 41. 2 | 0.14 | 14.18 | 1.22 | 10 |
| 21 | 26.37 | 1. 2 | 37.53 | 0.18 | 10.22 | 1.20 | 28.31 | 1. 3 | 40.54 | 0.17 | 12.55 | 1.23 | 9 |
| 22 | 27.37 | 1. 0 | 37.32 | 0.21 | 9. 2 | 1.20 | 29.32 | 1. 1 | 40.25 | 0.20 | 11.31 | 1.24 | 8 |
| 23 | 28.35 | 0.58 | 37. 8 | 0.24 | 7.41 | 1.21 | 30.31 | 0.59 | 40. 3 | 0.22 | 10. 7 | 1.24 | 7 |
| 24 | 29.31 | 0.56 | 36.41 | 0.27 | 6.20 | 1.21 | 31.28 | 0.57 | 39.38 | 0.25 | 8.42 | 1.25 | 6 |
| 25 | 30.25 | 0.54 | 36.10 | 0.31 | 4.58 | 1.22 | 32.22 | 0.54 | 39.10 | 0.28 | 7.16 | 1.26 | 5 |
| 26 | 31.16 | 0.51 | 35.37 | 0.33 | 3.36 | 1.22 | 33.14 | 0.52 | 38.39 | 0.31 | 5.50 | 1.26 | 4 |
| 27 | 32. 5 | 0.49 | 35. 2 | 0.35 | 2.13 | 1.23 | 34. 4 | 0.50 | 38. 5 | 0.34 | 4.23 | 1.27 | 3 |
| 28 | 32.51 | 0.46 | 34.24 | 0.38 | 0.50 | 1.23 | 34.52 | 0.48 | 37.29 | 0.36 | 2.56 | 1.27 | 2 |
| 29 | 33.35 | 0.44 | 33.44 | 0.40 | 0.33 | 1.23 | 35.38 | 0.46 | 36.50 | 0.39 | 1.28 | 1.28 | 1 |
| 30 | 34.17 | 0.42 | 33. 2 | 0.42 | 1.57 | 1.24 | 36.21 | 0.43 | 36. 8 | 0.42 | 0. 0 | 1.28 | 0 |
| 0 | — | | — | | ∓ | | + | | + | | + | | 0 |
| | 11 | | 10 | | 9 | | 8 | | 7 | | 6 | | |

## XIV. For Longitude of ☽ Reduction.

Argum. XIV.
Longit. ☽ in Orb — Longit. ☊ corr.

|  | 0. 6 | 1. 7 | 2. 8 |  |
|---|---|---|---|---|
|  | — | — | — |  |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 6. 2 | 6. 2 | 30 |
| 1 | 0. 14 | 6. 9 | 5. 55 | 29 |
| 2 | 0. 29 | 6. 15 | 5. 47 | 28 |
| 3 | 0. 43 | 6. 21 | 5. 39 | 27 |
| 4 | 0. 58 | 6. 27 | 5. 30 | 26 |
| 5 | 1. 12 | 6. 32 | 5. 20 | 25 |
| 6 | 1. 26 | 6. 37 | 5. 10 | 24 |
| 7 | 1. 41 | 6. 41 | 5. 0 | 23 |
| 8 | 1. 55 | 6. 45 | 4. 50 | 22 |
| 9 | 2. 9 | 6. 48 | 4. 39 | 21 |
| 10 | 2. 23 | 6. 51 | 4. 28 | 20 |
| 11 | 2. 37 | 6. 54 | 4. 17 | 19 |
| 12 | 2. 50 | 6. 56 | 4. 5 | 18 |
| 13 | 3. 3 | 6. 57 | 3. 53 | 17 |
| 14 | 3. 16 | 6. 57 | 3. 41 | 16 |
| 15 | 3. 29 | 6. 57 | 3. 29 | 15 |
| 16 | 3. 41 | 6. 57 | 3. 16 | 14 |
| 17 | 3. 53 | 6. 57 | 3. 3 | 13 |
| 18 | 4. 5 | 6. 56 | 2. 50 | 12 |
| 19 | 4. 17 | 6. 54 | 2. 37 | 11 |
| 20 | 4. 28 | 6. 51 | 2. 23 | 10 |
| 21 | 4. 39 | 6. 48 | 2. 9 | 9 |
| 22 | 4. 50 | 6. 45 | 1. 55 | 8 |
| 23 | 5. 0 | 6. 41 | 1. 41 | 7 |
| 24 | 5. 10 | 6. 37 | 1. 26 | 6 |
| 25 | 5. 20 | 6. 32 | 1. 12 | 5 |
| 26 | 5. 30 | 6. 27 | 0. 58 | 4 |
| 27 | 5. 39 | 6. 21 | 0. 43 | 3 |
| 28 | 5. 47 | 6. 15 | 0. 29 | 2 |
| 29 | 5. 55 | 6. 9 | 0. 14 | 1 |
| 30 | 6. 2 | 6. 2 | 0. 0 | 0 |
|  | + | + | + | 0 |
|  | 11. 5 | 10. 4 | 9. 3 |  |

## I. For the Latitude of the Moon.

Argum. I.
Longitude ☽ in Orbit—Longitude of ☊ correct.

|  | 0. N |  | 1. N |  | 2. N |  |  |
|---|---|---|---|---|---|---|---|
|  | 6. S |  | 7. S |  | 8. S |  |  |
| ° | ° ′ ″ | Diff. | ° ′ ″ | Diff. | ° ′ ″ | Diff. | ° |
| 0 | 0. 0. 0 | 5. 23 | 2. 34. 25 | 4. 39 | 4. 27. 38 | 2. 40 | 30 |
| 1 | 0. 5. 23 | 5. 23 | 2. 39. 4 | 4. 35 | 4. 30. 18 | 2. 35 | 29 |
| 2 | 0. 10. 46 | 5. 23 | 2. 43. 39 | 4. 33 | 4. 32. 53 | 2. 29 | 28 |
| 3 | 0. 16. 9 | 5. 23 | 2. 48. 12 | 4. 30 | 4. 35. 22 | 2. 25 | 27 |
| 4 | 0. 21. 32 | 5. 22 | 2. 52. 42 | 4. 27 | 4. 37. 47 | 2. 20 | 26 |
| 5 | 0. 26. 54 | 5. 22 | 2. 57. 9 | 4. 24 | 4. 40. 7 | 2. 14 | 25 |
| 6 | 0. 32. 16 | 5. 21 | 3. 1. 33 | 4. 20 | 4. 42. 21 | 2. 9 | 24 |
| 7 | 0. 37. 37 | 5. 21 | 3. 5. 53 | 4. 17 | 4. 44. 30 | 2. 4 | 23 |
| 8 | 0. 42. 58 | 5. 20 | 3. 10. 10 | 4. 13 | 4. 46. 34 | 1. 59 | 22 |
| 9 | 0. 48. 18 | 5. 19 | 3. 14. 23 | 4. 10 | 4. 48. 33 | 1. 54 | 21 |
| 10 | 0. 53. 37 | 5. 18 | 3. 18. 33 | 4. 6 | 4. 50. 27 | 1. 48 | 20 |
| 11 | 0. 58. 55 | 5. 16 | 3. 22. 39 | 4. 3 | 4. 52. 15 | 1. 43 | 19 |
| 12 | 1. 4. 11 | 5. 16 | 3. 26. 42 | 3. 59 | 4. 53. 58 | 1. 38 | 18 |
| 13 | 1. 9. 27 | 5. 15 | 3. 30. 41 | 3. 55 | 4. 55. 36 | 1. 32 | 17 |
| 14 | 1. 14. 42 | 5. 13 | 3. 34. 36 | 3. 51 | 4. 57. 8 | 1. 27 | 16 |
| 15 | 1. 19. 55 | 5. 11 | 3. 38. 27 | 3. 47 | 4. 58. 35 | 1. 21 | 15 |
| 16 | 1. 25. 6 | 5. 10 | 3. 42. 14 | 3. 43 | 4. 59. 56 | 1. 16 | 14 |
| 17 | 1. 30. 16 | 5. 8 | 3. 45. 57 | 3. 39 | 5. 1. 12 | 1. 10 | 13 |
| 18 | 1. 35. 24 | 5. 7 | 3. 49. 36 | 3. 35 | 5. 2. 22 | 1. 4 | 12 |
| 19 | 1. 40. 31 | 5. 5 | 3. 53. 11 | 3. 30 | 5. 3. 26 | 0. 59 | 11 |
| 20 | 1. 45. 36 | 5. 3 | 3. 56. 41 | 3. 26 | 5. 4. 25 | 0. 54 | 10 |
| 21 | 1. 50. 39 | 5. 1 | 4. 0. 7 | 3. 22 | 5. 5. 19 | 0. 48 | 9 |
| 22 | 1. 55. 40 | 4. 59 | 4. 3. 29 | 3. 18 | 5. 6. 7 | 0. 43 | 8 |
| 23 | 2. 0. 39 | 4. 57 | 4. 6. 47 | 3. 12 | 5. 6. 50 | 0. 36 | 7 |
| 24 | 2. 5. 36 | 4. 54 | 4. 9. 59 | 3. 8 | 5. 7. 26 | 0. 31 | 6 |
| 25 | 2. 10. 30 | 4. 52 | 4. 13. 7 | 3. 4 | 5. 7. 57 | 0. 26 | 5 |
| 26 | 2. 15. 22 | 4. 50 | 4. 16. 11 | 2. 59 | 5. 8. 23 | 0. 20 | 4 |
| 27 | 2. 20. 12 | 4. 47 | 4. 19. 10 | 2. 54 | 5. 8. 43 | 0. 14 | 3 |
| 28 | 2. 24. 59 | 4. 44 | 4. 22. 4 | 2. 49 | 5. 8. 57 | 0. 8 | 2 |
| 29 | 2. 29. 43 | 4. 42 | 4. 24. 53 | 2. 45 | 5. 9. 5 | 0. 3 | 1 |
| 30 | 2. 34. 25 |  | 4. 27. 38 |  | 5. 9. 8 |  | 0 |
| 0 | 11. S |  | 10. S |  | 9. S |  |  |
|  | 5. N |  | 4. N |  | 3. N |  |  |

### II. For Latitude of ☽

Argum. II.
Argu. IX + Argu. XIII.

| | 0.N | 1.N | 2.N | |
|---|---|---|---|---|
| | 6. S | 7. S | 8. S | |
| ° | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 0. 0 | 4. 25 | 7. 39 | 30 |
| 1 | 0. 9 | 4. 33 | 7. 43 | 29 |
| 2 | 0. 19 | 4. 41 | 7. 48 | 28 |
| 3 | 0. 28 | 4. 49 | 7. 52 | 27 |
| 4 | 0. 37 | 4. 56 | 7. 56 | 26 |
| 5 | 0. 46 | 5. 4 | 8. 0 | 25 |
| 6 | 0. 55 | 5. 11 | 8. 4 | 24 |
| 7 | 1. 5 | 5. 19 | 8. 7 | 23 |
| 8 | 1. 14 | 5. 26 | 8. 11 | 22 |
| 9 | 1. 23 | 5. 34 | 8. 14 | 21 |
| 10 | 1. 32 | 5. 41 | 8. 18 | 20 |
| 11 | 1. 41 | 5. 48 | 8. 21 | 19 |
| 12 | 1. 50 | 5. 55 | 8. 24 | 18 |
| 13 | 1. 59 | 6. 2 | 8. 27 | 17 |
| 14 | 2. 8 | 6. 9 | 8. 30 | 16 |
| 15 | 2. 17 | 6. 15 | 8. 32 | 15 |
| 16 | 2. 26 | 6. 22 | 8. 34 | 14 |
| 17 | 2. 35 | 6. 28 | 8. 36 | 13 |
| 18 | 2. 44 | 6. 34 | 8. 38 | 12 |
| 19 | 2. 52 | 6. 40 | 8. 40 | 11 |
| 20 | 3. 1 | 6. 46 | 8. 42 | 10 |
| 21 | 3. 10 | 6. 52 | 8. 43 | 9 |
| 22 | 3. 18 | 6. 57 | 8. 45 | 8 |
| 23 | 3. 27 | 7. 3 | 8. 46 | 7 |
| 24 | 3. 35 | 7. 8 | 8. 47 | 6 |
| 25 | 3. 44 | 7. 14 | 8. 48 | 5 |
| 26 | 3. 52 | 7. 19 | 8. 48 | 4 |
| 27 | 4. 1 | 7. 24 | 8. 49 | 3 |
| 28 | 4. 9 | 7. 29 | 8. 49 | 2 |
| 29 | 4. 17 | 7. 34 | 8. 50 | 1 |
| 30 | 4. 25 | 7. 39 | 8. 50 | 0 |
| ° | 11. S | 10.S | 9. S | ° |
| | 5.N | 4.N | 3.N | |

### I. For Equatorial Parallax of ☽

Arg. Long. XI.
Anomaly of ☽ correct.

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| | Parall. | Parall. | Parall. | Parall. | Parall. | Parall | |
| ° | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ′ ″ | ° |
| 0 | 54. 10 | 54. 30 | 55. 29 | 56. 58 | 58. 37 | 59. 56 | 30 |
| 1 | 54. 10 | 54. 32 | 55. 32 | 57. 1 | 58. 40 | 59. 58 | 29 |
| 2 | 54. 10 | 54. 33 | 55. 34 | 57. 5 | 58. 43 | 60. 0 | 28 |
| 3 | 54. 10 | 54. 35 | 55. 37 | 57. 8 | 58. 46 | 60. 2 | 27 |
| 4 | 54. 11 | 54. 36 | 55. 39 | 57. 12 | 58. 49 | 60. 4 | 26 |
| 5 | 54. 11 | 54. 38 | 55. 42 | 57. 15 | 58. 52 | 60. 5 | 25 |
| 6 | 54. 11 | 54. 39 | 55. 45 | 57. 19 | 58. 55 | 60. 7 | 2 |
| 7 | 54. 11 | 54. 41 | 55. 47 | 57. 22 | 58. 58 | 60. 8 | 23 |
| 8 | 54. 11 | 54. 42 | 55. 50 | 57. 25 | 59. 1 | 60. 10 | 22 |
| 9 | 54. 12 | 54. 44 | 55. 53 | 57. 29 | 59. 4 | 60. 11 | 21 |
| 10 | 54. 12 | 54. 46 | 55. 56 | 57. 32 | 59. 7 | 60. 13 | 20 |
| 11 | 54. 12 | 54. 48 | 55. 59 | 57. 35 | 59. 10 | 60. 14 | 19 |
| 12 | 54. 13 | 54. 49 | 56. 2 | 57. 38 | 59. 13 | 60. 15 | 18 |
| 13 | 54. 13 | 54. 51 | 56. 5 | 57. 42 | 59. 16 | 60. 16 | 17 |
| 14 | 54. 14 | 54. 53 | 56. 8 | 57. 45 | 59. 18 | 60. 17 | 16 |
| 15 | 54. 15 | 54. 55 | 56. 11 | 57. 48 | 59. 21 | 60. 18 | 15 |
| 16 | 54. 15 | 54. 57 | 56. 14 | 57. 51 | 59. 23 | 60. 18 | 14 |
| 17 | 54. 16 | 54. 59 | 56. 17 | 57. 55 | 59. 26 | 60. 19 | 13 |
| 18 | 54. 17 | 55. 1 | 56. 20 | 57. 58 | 59. 29 | 60. 20 | 12 |
| 19 | 54. 18 | 55. 3 | 56. 23 | 58. 1 | 59. 31 | 60. 21 | 11 |
| 20 | 54. 19 | 55. 5 | 56. 26 | 58. 4 | 59. 34 | 60. 22 | 10 |
| 21 | 54. 20 | 55. 7 | 56. 29 | 58. 8 | 59. 36 | 60. 22 | 9 |
| 22 | 54. 21 | 55. 9 | 56. 32 | 58. 11 | 59. 39 | 60. 23 | 8 |
| 23 | 54. 22 | 55. 12 | 56. 36 | 58. 14 | 59. 41 | 60. 24 | 7 |
| 24 | 54. 23 | 55. 14 | 56. 39 | 58. 18 | 59. 44 | 60. 25 | 6 |
| 25 | 54. 24 | 55. 17 | 56. 42 | 58. 21 | 59. 46 | 60. 25 | 5 |
| 26 | 54. 25 | 55. 19 | 56. 45 | 58. 24 | 59. 48 | 60. 26 | 4 |
| 27 | 54. 26 | 55. 22 | 56. 49 | 58. 28 | 59. 50 | 60. 26 | 3 |
| 28 | 54. 28 | 55. 24 | 56. 52 | 58. 31 | 59. 52 | 60. 26 | 2 |
| 29 | 54. 29 | 55. 27 | 56. 55 | 58. 34 | 59. 54 | 60. 26 | 1 |
| 30 | 54. 30 | 55. 29 | 56. 58 | 58. 37 | 59. 56 | 60. 26 | 0 |
| ° | Parall. | Parall. | Parall. | Parall | Parall. | Parall. | ° |
| | 11 | 10 | 9 | 8 | 7 | 6 | |

### II. For Parallax of the ☽

Arg. Long. XII.
Double Diſt. ☽ *a* ☉ correct — Anom. ☽ corr.

| | 0 | 1 | 2 | |
|---|---|---|---|---|
| | 6 | 7 | 8 | |
| | + | + | + | |
| ° | ″ | ″ | ″ | ° |
| 0 | 38 | 33 | 19 | 30 |
| 1 | 38 | 32 | 18 | 29 |
| 2 | 38 | 32 | 18 | 28 |
| 3 | 38 | 32 | 17 | 27 |
| 4 | 38 | 31 | 17 | 26 |
| 5 | 38 | 31 | 16 | 25 |
| 6 | 38 | 31 | 16 | 24 |
| 7 | 37 | 30 | 15 | 23 |
| 8 | 37 | 30 | 14 | 22 |
| 9 | 37 | 30 | 14 | 21 |
| 10 | 37 | 29 | 13 | 20 |
| 11 | 37 | 29 | 13 | 19 |
| 12 | 37 | 28 | 12 | 18 |
| 13 | 37 | 28 | 11 | 17 |
| 14 | 36 | 28 | 11 | 16 |
| 15 | 36 | 27 | 10 | 15 |
| 16 | 36 | 27 | 9 | 14 |
| 17 | 36 | 26 | 9 | 13 |
| 18 | 36 | 26 | 8 | 12 |
| 19 | 35 | 25 | 7 | 11 |
| 20 | 35 | 25 | 6 | 10 |
| 21 | 35 | 24 | 6 | 9 |
| 22 | 35 | 24 | 5 | 8 |
| 23 | 34 | 23 | 4 | 7 |
| 24 | 34 | 23 | 4 | 6 |
| 25 | 34 | 22 | 3 | 5 |
| 26 | 34 | 21 | 3 | 4 |
| 27 | 33 | 21 | 2 | 3 |
| 28 | 33 | 20 | 1 | 2 |
| 29 | 33 | 20 | 1 | 1 |
| 30 | 33 | 19 | 0 | 0 |
| 0 | 11 | 10 | 9 | 0 |
| | + | + | + | |
| | 5 | 4 | 3 | |

### III. For Equator Parallax of the ☽

Arg. Long. XIII.
Longitude ☽ Equated — true Longitude ☉

| | 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| | + | ± | — | — | ∓ | + | |
| ° | ″ | ″ | ″ | ″ | ″ | ″ | ° |
| 0 | 25 | 12 | 14 | 27 | 13 | 14 | 30 |
| 1 | 25 | 12 | 14 | 27 | 12 | 14 | 29 |
| 2 | 25 | 11 | 15 | 27 | 12 | 15 | 28 |
| 3 | 25 | 10 | 16 | 27 | 11 | 16 | 27 |
| 4 | 25 | 9 | 16 | 27 | 10 | 17 | 26 |
| 5 | 25 | 8 | 17 | 27 | 9 | 18 | 25 |
| 6 | 25 | 8 | 18 | 27 | 8 | 18 | 24 |
| 7 | 24 | 7 | 18 | 26 | 7 | 19 | 23 |
| 8 | 24 | 6 | 19 | 26 | 6 | 20 | 22 |
| 9 | 24 | 5 | 20 | 26 | 5 | 20 | 21 |
| 10 | 24 | 4 | 21 | 25 | 4 | 21 | 20 |
| 11 | 24 | 3 | 21 | 25 | 3 | 22 | 19 |
| 12 | 23 | 2 | 22 | 24 | 2 | 22 | 18 |
| 13 | 23 | 1 | 23 | 24 | 1 | 23 | 17 |
| 14 | 23 | 0 | 23 | 23 | 0 | 23 | 16 |
| 15 | 23 | 1 | 24 | 23 | 1 | 24 | 15 |
| 16 | 22 | 1 | 24 | 22 | 2 | 24 | 14 |
| 17 | 22 | 2 | 25 | 22 | 3 | 25 | 13 |
| 18 | 21 | 3 | 25 | 21 | 4 | 25 | 12 |
| 19 | 20 | 4 | 25 | 21 | 5 | 25 | 11 |
| 20 | 19 | 5 | 26 | 20 | 6 | 26 | 10 |
| 21 | 19 | 6 | 26 | 19 | 7 | 26 | 9 |
| 22 | 18 | 7 | 26 | 19 | 7 | 26 | 8 |
| 23 | 17 | 8 | 26 | 18 | 8 | 26 | 7 |
| 24 | 17 | 9 | 26 | 17 | 9 | 27 | 6 |
| 25 | 16 | 10 | 27 | 16 | 10 | 27 | 5 |
| 26 | 15 | 10 | 27 | 16 | 11 | 27 | 4 |
| 27 | 15 | 11 | 27 | 15 | 11 | 28 | 3 |
| 28 | 14 | 12 | 27 | 14 | 12 | 28 | 2 |
| 29 | 13 | 13 | 27 | 13 | 13 | 28 | 1 |
| 30 | 12 | 14 | 27 | 13 | 14 | 28 | 0 |
| 0 | + | ± | — | — | ± | + | 0 |
| | 11 | 10 | 9 | 8 | 7 | 6 | |

### To find the ☽'s Horizontal Semidiameter from the Equat. Paral.

| *Parall.* | *Semidi.* | *Parall.* | *Semidi.* |
|---|---|---|---|
| ′ ″ | ′ ″ | ′ ″ | ′ ″ |
| 53. 10 | 14. 30 | 57. 23 | 15. 39 |
| 53. 21 | 14. 33 | 57. 34 | 15. 42 |
| 53. 32 | 14. 36 | 57. 45 | 15. 45 |
| 53. 43 | 14. 39 | 57. 56 | 15. 48 |
| 53. 54 | 14. 42 | 58. 7 | 15. 51 |
| 54. 5 | 14. 45 | 58. 18 | 15. 54 |
| 54. 16 | 14. 48 | 58. 29 | 15. 57 |
| 54. 27 | 14. 51 | 58. 40 | 16. 0 |
| 54. 38 | 14. 54 | 58. 51 | 16. 3 |
| 54. 49 | 14. 57 | 59. 2 | 16. 6 |
| 55. 0 | 15. 0 | 59. 13 | 16. 9 |
| 55. 11 | 15. 3 | 59. 24 | 16. 12 |
| 55. 22 | 15. 6 | 59. 35 | 16. 15 |
| 55. 33 | 15. 9 | 59. 46 | 16. 18 |
| 55. 44 | 15. 12 | 59. 57 | 16. 21 |
| 55. 55 | 15. 15 | 60. 8 | 16. 24 |
| 56. 6 | 15. 18 | 60. 19 | 16. 27 |
| 56. 17 | 15. 21 | 60. 30 | 16. 30 |
| 56. 28 | 15. 24 | 60. 41 | 16. 33 |
| 56. 39 | 15. 27 | 60. 52 | 16. 36 |
| 56. 50 | 15. 30 | 61. 3 | 16. 39 |
| 57. 1 | 15. 33 | 61. 14 | 16. 42 |
| 57. 12 | 15. 36 | 61. 25 | 16. 45 |

### Increaſe of the ☽'s Semidiameter for different Altit.

| Appt. Altit. ☽ | Incre. of ☽'s Semi. | Appt. Altit. ☽ | Incre. of ☽'s Semi. |
|---|---|---|---|
| ° | ″ | ° | ″ |
| 0 | 0 | 50 | 12 |
| 5 | 1 | 55 | 13 |
| 10 | 3 | 60 | 14 |
| 15 | 4 | | |
| 20 | 6 | 65 | 15 |
| 25 | 7 | 70 | 15 |
| 30 | 8 | 75 | 16 |
| 35 | 9 | 80 | 16 |
| 40 | 10 | 85 | 16 |
| 45 | 11 | 90 | 16 |

## I. For the hourly Motion of the Moon in Orbit.

Argum. Long. XI.
Anomaly of ☽ correct.

| ° | 0<br>′ ″ | 1<br>′ ″ | 2<br>′ ″ | 3<br>′ ″ | 4<br>′ ″ | 5<br>′ ″ | ° |
|---|---|---|---|---|---|---|---|
| 0 | 29. 36 | 29. 57 | 31. 2 | 32. 41 | 34. 36 | 36. 9 | 30 |
| 1 | 29. 36 | 29. 59 | 31. 4 | 32. 45 | 34. 40 | 36. 12 | 29 |
| 2 | 29. 36 | 30. 0 | 31. 7 | 32. 49 | 34. 44 | 36. 14 | 28 |
| 3 | 29. 36 | 30. 2 | 31. 9 | 32. 52 | 34. 47 | 36. 17 | 27 |
| 4 | 29. 37 | 30. 3 | 31. 13 | 32. 56 | 34. 51 | 36. 18 | 26 |
| 5 | 29. 37 | 30. 5 | 31. 15 | 33. 0 | 34. 54 | 36. 20 | 25 |
| 6 | 29. 37 | 30. 7 | 31. 19 | 33. 4 | 34. 57 | 36. 22 | 24 |
| 7 | 29. 37 | 30. 8 | 31. 22 | 33. 8 | 35. 1 | 36. 24 | 23 |
| 8 | 29. 37 | 30. 11 | 31. 24 | 33. 12 | 35. 4 | 36. 26 | 22 |
| 9 | 29. 38 | 30. 12 | 31. 28 | 33. 16 | 35. 8 | 36. 28 | 21 |
| 10 | 29. 38 | 30. 14 | 31. 31 | 33. 19 | 35. 11 | 36. 30 | 20 |
| 11 | 29. 39 | 30. 16 | 31. 34 | 33. 23 | 35. 15 | 36. 31 | 19 |
| 12 | 29. 40 | 30. 17 | 31. 38 | 33. 27 | 35. 19 | 36. 32 | 18 |
| 13 | 29. 40 | 30. 20 | 31. 41 | 33. 31 | 35. 22 | 36. 34 | 17 |
| 14 | 29. 40 | 30. 21 | 31. 45 | 33. 35 | 35. 25 | 36. 35 | 16 |
| 15 | 29. 41 | 30. 24 | 31. 47 | 33. 39 | 35. 28 | 36. 37 | 15 |
| 16 | 29. 42 | 30. 27 | 31. 51 | 33. 43 | 35. 31 | 36. 38 | 14 |
| 17 | 29. 42 | 30. 28 | 31. 55 | 33. 47 | 35. 34 | 36. 39 | 13 |
| 18 | 29. 44 | 30. 31 | 31. 57 | 33. 50 | 35. 37 | 36. 40 | 12 |
| 19 | 29. 45 | 30. 33 | 32. 1 | 33. 54 | 35. 40 | 36. 41 | 11 |
| 20 | 29. 45 | 30. 35 | 32. 5 | 33. 58 | 35. 44 | 36. 42 | 10 |
| 21 | 29. 46 | 30. 38 | 32. 8 | 34. 2 | 35. 46 | 36. 43 | 9 |
| 22 | 29. 48 | 30. 40 | 32. 12 | 34. 6 | 35. 49 | 36. 43 | 8 |
| 23 | 29. 49 | 30. 43 | 32. 16 | 34. 9 | 35. 52 | 36. 44 | 7 |
| 24 | 29. 50 | 30. 45 | 32. 19 | 34. 13 | 35. 55 | 36. 45 | 6 |
| 25 | 29. 51 | 30. 48 | 32. 22 | 34. 17 | 35. 57 | 36. 45 | 5 |
| 26 | 29. 52 | 30. 51 | 32. 26 | 34. 21 | 35. 59 | 36. 45 | 4 |
| 27 | 29. 53 | 30. 53 | 32. 30 | 34. 25 | 36. 2 | 36. 46 | 3 |
| 28 | 29. 54 | 30. 56 | 32. 34 | 34. 29 | 36. 4 | 36. 46 | 2 |
| 29 | 29. 56 | 30. 58 | 32. 37 | 34. 32 | 36. 7 | 36. 46 | 1 |
| 30 | 29. 57 | 31. 2 | 32 41 | 34. 36 | 36. 9 | 36. 46 | 0 |
| ° | 11 | 10 | 9 | 8 | 7 | 6 | ° |

## II. For hourly Motion of ☽

Arg. Lon. XII.
Double Dist. ☽ a ☉
corr. — Anoma.
☽ corr.

| ° | 0<br>—<br>6<br>+<br>″ | 1<br>—<br>7<br>+<br>″ | 2<br>—<br>8<br>+<br>″ | ° |
|---|---|---|---|---|
| 0 | 38 | 33 | 19 | 30 |
| 1 | 38 | 32 | 18 | 29 |
| 2 | 38 | 32 | 18 | 28 |
| 3 | 38 | 32 | 17 | 27 |
| 4 | 38 | 31 | 17 | 26 |
| 5 | 38 | 31 | 16 | 25 |
| 6 | 38 | 31 | 16 | 24 |
| 7 | 37 | 30 | 15 | 23 |
| 8 | 37 | 30 | 14 | 22 |
| 9 | 37 | 30 | 14 | 21 |
| 10 | 37 | 29 | 13 | 20 |
| 11 | 37 | 29 | 13 | 19 |
| 12 | 37 | 28 | 12 | 18 |
| 13 | 37 | 28 | 11 | 17 |
| 14 | 36 | 28 | 11 | 16 |
| 15 | 36 | 27 | 10 | 15 |
| 16 | 36 | 27 | 9 | 14 |
| 17 | 36 | 26 | 9 | 13 |
| 18 | 36 | 26 | 8 | 12 |
| 19 | 35 | 25 | 7 | 11 |
| 20 | 35 | 25 | 6 | 10 |
| 21 | 35 | 24 | 6 | 9 |
| 22 | 35 | 24 | 5 | 8 |
| 23 | 34 | 23 | 4 | 7 |
| 24 | 34 | 23 | 4 | 6 |
| 25 | 34 | 22 | 3 | 5 |
| 26 | 34 | 21 | 3 | 4 |
| 27 | 33 | 21 | 2 | 3 |
| 28 | 33 | 20 | 1 | 2 |
| 29 | 33 | 20 | 1 | 1 |
| 30 | 33 | 19 | 0 | 0 |
|  | —<br>11<br>+<br>5 | —<br>10<br>+<br>4 | —<br>9<br>+<br>3 | 0 |

III. For hourly Mot. of ☽

Argum. III.
Mean Dist. of ☉ *a* ☽.

| S<br>S | 0<br>6 | 1<br>7 | 2<br>8 | 3<br>9 | 4<br>10 | 5<br>11 |
|---|---|---|---|---|---|---|
|  | + | + | − | − | + | + |
| ° | ′ | ″ | ″ | ″ | ″ | ″ |
| 0 | 42 | 21 | 21 | 42 | 21 | 21 |
| 1 | 42 | 20 | 22 | 42 | 20 | 22 |
| 2 | 42 | 18 | 24 | 42 | 18 | 24 |
| 3 | 42 | 17 | 24 | 42 | 17 | 24 |
| 4 | 42 | 15 | 26 | 42 | 15 | 26 |
| 5 | 42 | 14 | 27 | 42 | 14 | 27 |
| 6 | 42 | 13 | 28 | 42 | 13 | 28 |
| 7 | 41 | 11 | 29 | 41 | 11 | 29 |
| 8 | 41 | 10 | 30 | 41 | 10 | 30 |
| 9 | 40 | 8 | 31 | 40 | 8 | 31 |
| 10 | 40 | 7 | 32 | 40 | 7 | 32 |
| 11 | 39 | 5 | 33 | 39 | 5 | 33 |
| 12 | 39 | 4 | 34 | 39 | 4 | 34 |
| 13 | 38 | 2 | 35 | 38 | 2 | 35 |
| 14 | 37 | 1 | 36 | 37 | 1 | 36 |
| 15 | 36 | 0 | 36 | 36 | 0 | 36 |
|  |  | − |  |  | + |  |
| 16 | 36 | 1 | 37 | 36 | 1 | 37 |
| 17 | 35 | 3 | 38 | 35 | 3 | 38 |
| 18 | 34 | 5 | 39 | 34 | 5 | 39 |
| 19 | 33 | 6 | 39 | 33 | 6 | 39 |
| 20 | 32 | 8 | 40 | 32 | 8 | 40 |
| 21 | 31 | 9 | 40 | 31 | 9 | 40 |
| 22 | 30 | 10 | 41 | 30 | 10 | 41 |
| 23 | 29 | 12 | 41 | 29 | 12 | 41 |
| 24 | 28 | 13 | 42 | 28 | 13 | 42 |
| 25 | 27 | 14 | 42 | 27 | 14 | 42 |
| 26 | 26 | 15 | 42 | 26 | 15 | 42 |
| 27 | 24 | 17 | 42 | 24 | 17 | 42 |
| 28 | 24 | 18 | 42 | 24 | 18 | 42 |
| 29 | 22 | 20 | 42 | 22 | 20 | 42 |
| 30 | 21 | 21 | 42 | 21 | 21 | 42 |

A Table of the Multipliers of the Difference between the Moon's Longitude computed, and that inferred from Obſervation; to find the Error of the Ship's Account in Longitude.

Enter with hourly Motion of ☽, or difference of hourly Motions of ☉ & ☽, according as ☽'s diſtance is taken from a Star or the Sun.

| Ho. Mo. ☽ or diffe. Ho. Mot. ☉ *a* ☽. | Multi-pliers. | Ho. Mot. ☽ or diffe. Ho. Mot. ☉ *a* ☽. | Multi-pliers. |
|---|---|---|---|
| ′ ″ |  | ′ ″ |  |
| 25. 45 | 35,0 | 32. 0 | 28,1 |
| 26. 0 | 34,6 | 32. 15 | 27,9 |
| 26. 15 | 34,3 | 32. 30 | 27,7 |
| 26. 30 | 34,0 | 32. 45 | 27,5 |
| 26. 45 | 33,6 | 33. 0 | 27,3 |
| 27. 0 | 33,3 | 33. 15 | 27,1 |
| 27. 15 | 33,0 | 33. 30 | 26,9 |
| 27. 30 | 32,7 | 33. 45 | 26,7 |
| 27. 45 | 32,4 | 34. 0 | 26,5 |
| 28. 0 | 32,1 | 34. 15 | 26,3 |
| 28. 15 | 31,8 | 34. 30 | 26,1 |
| 28. 30 | 31,6 | 34. 45 | 25,9 |
| 28. 45 | 31,3 | 35. 0 | 25,7 |
| 29. 0 | 31,0 | 35. 15 | 25,5 |
| 29. 15 | 30,8 | 35. 30 | 25,3 |
| 29. 30 | 30,5 | 35. 45 | 25,2 |
| 29. 45 | 30,2 | 36. 0 | 25,0 |
| 30. 0 | 30,0 | 36. 15 | 24,8 |
| 30. 15 | 29,7 | 36. 30 | 24,7 |
| 30. 30 | 29,5 | 36. 45 | 24,5 |
| 30. 45 | 29,3 | 37. 0 | 24,3 |
| 31. 0 | 29,0 | 37. 15 | 24,2 |
| 31. 15 | 28,8 | 37. 30 | 24,0 |
| 31. 30 | 28,6 | 37. 45 | 23,8 |
| 31. 45 | 28,3 | 38. 0 | 23,7 |

## A Table of the Declination of the Degrees of the Ecliptic.

|  | 0 N | 1 N | 2 N |  |
|---|---|---|---|---|
|  | 6 S | 7 S | 8 S |  |
| ° | ° ′ | ° ′ | ° ′ | ° |
| 0 | 0. 0 | 11. 29 | 20. 11 | 30 |
| 1 | 0. 24 | 11. 50 | 20. 23 | 29 |
| 2 | 0. 48 | 12. 11 | 20. 35 | 28 |
| 3 | 1. 12 | 12. 32 | 20. 47 | 27 |
| 4 | 1. 35 | 12. 52 | 20. 59 | 26 |
| 5 | 1. 59 | 13. 12 | 21. 10 | 25 |
| 6 | 2. 23 | 13: 32 | 21. 20 | 24 |
| 7 | 2. 47 | 13. 52 | 21. 30 | 23 |
| 8 | 3. 11 | 14. 12 | 21. 40 | 22 |
| 9 | 3. 34 | 14. 31 | 21. 50 | 21 |
| 10 | 3. 58 | 14. 50 | 21. 59 | 20 |
| 11 | 4. 21 | 15. 9 | 22. 7 | 19 |
| 12 | 4. 45 | 15. 27 | 22. 16 | 18 |
| 13 | 5. 8 | 15. 46 | 22. 23 | 17 |
| 14 | 5. 32 | 16. 4 | 22. 31 | 16 |
| 15 | 5. 55 | 16. 21 | 22. 38 | 15 |
| 16 | 6. 18 | 16. 39 | 22. 44 | 14 |
| 17 | 6. 41 | 16. 56 | 22. 50 | 13 |
| 18 | 7. 4 | 17. 13 | 22. 56 | 12 |
| 19 | 7. 27 | 17. 30 | 23. 1 | 11 |
| 20 | 7. 50 | 17. 46 | 23. 6 | 10 |
| 21 | 8. 12 | 18. 2 | 23. 10 | 9 |
| 22 | 8. 35 | 18. 17 | 23. 14 | 8 |
| 23 | 8. 57 | 18. 33 | 23. 17 | 7 |
| 24 | 9. 19 | 18. 48 | 23. 20 | 6 |
| 25 | 9. 41 | 19. 2 | 23. 23 | 5 |
| 26 | 10. 3 | 19. 17 | 23. 25 | 4 |
| 27 | 10. 25 | 19. 31 | 23. 26 | 3 |
| 28 | 10. 46 | 19. 44 | 23. 27 | 2 |
| 29 | 11. 8 | 19. 58 | 23. 28 | 1 |
| 30 | 11. 29 | 20. 11 | 23. 28 | 0 |
|  | 5 N | 4 N | 3. N | ° |
|  | 11 S | 10 S | 9. S |  |

## A Table of the Moon's Parallax in Altitude.

| ☽'s Ap. Altit. | Horizontal Parallax of ☽. |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| ° | ′<br>53 | ′<br>54 | ′<br>55 | ′<br>56 | ′<br>57 | ′<br>58 | ′<br>59 | ′<br>60 | ′<br>61 | ′<br>62 |
| 0 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| 9 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| 12 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| 15 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 18 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| 21 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 |
| 24 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 |
| 27 | 47 | 48 | 49 | 50 | 51 | 52 | 52 | 53 | 54 | 55 |
| 30 | 46 | 47 | 48 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| 33 | 44 | 45 | 46 | 47 | 48 | 48 | 49 | 50 | 51 | 52 |
| 36 | 43 | 44 | 44 | 45 | 46 | 47 | 48 | 48 | 49 | 50 |
| 39 | 41 | 42 | 43 | 43 | 44 | 45 | 45 | 46 | 47 | 48 |
| 42 | 39 | 40 | 41 | 41 | 42 | 43 | 44 | 44 | 45 | 46 |
| 45 | 37 | 38 | 39 | 39 | 40 | 41 | 42 | 42 | 44 | 44 |
| 48 | 35 | 36 | 37 | 37 | 38 | 39 | 39 | 40 | 41 | 41 |
| 51 | 33 | 34 | 35 | 35 | 36 | 36 | 37 | 38 | 38 | 39 |
| 54 | 31 | 32 | 32 | 33 | 33 | 34 | 35 | 35 | 36 | 36 |
| 57 | 29 | 29 | 30 | 30 | 31 | 32 | 32 | 33 | 33 | 34 |
| 60 | 27 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 |
| 63 | 24 | 24 | 25 | 25 | 26 | 26 | 27 | 27 | 28 | 28 |
| 66 | 21 | 22 | 22 | 23 | 23 | 23 | 24 | 24 | 25 | 25 |
| 69 | 19 | 19 | 20 | 20 | 20 | 21 | 21 | 21 | 22 | 22 |
| 72 | 16 | 17 | 17 | 17 | 18 | 18 | 18 | 18 | 19 | 19 |
| 75 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 |
| 78 | 11 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 13 |
| 81 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 10 | 10 |
| 84 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 87 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## A Table of the right Aſcenſion of the Degrees of the Ecliptic.

| | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| ° | ° ' | ° ' | ° ' | ° ' | ° ' | ° ' |
| 0 | 0. 0 | 27. 54 | 57. 49 | 90. 0 | 122. 11 | 152. 6 |
| 1 | 0. 55 | 28. 51 | 58. 51 | 91. 5 | 123. 14 | 153. 3 |
| 2 | 1. 50 | 29. 49 | 59. 54 | 92. 11 | 124. 16 | 154. 0 |
| 3 | 2. 45 | 30. 47 | 60. 57 | 93. 16 | 125. 18 | 154. 57 |
| 4 | 3. 40 | 31. 45 | 62. 0 | 94. 21 | 126. 20 | 155. 54 |
| 5 | 4. 35 | 32. 43 | 63. 3 | 95. 27 | 127. 21 | 156. 50 |
| 6 | 5. 30 | 33. 41 | 64. 6 | 96. 32 | 128. 23 | 157. 47 |
| 7 | 6. 26 | 34. 39 | 65. 10 | 97. 37 | 129. 24 | 158. 44 |
| 8 | 7. 21 | 35. 38 | 66. 14 | 98. 43 | 130. 25 | 159. 40 |
| 9 | 8. 16 | 36. 36 | 67. 17 | 99. 48 | 131. 26 | 160. 36 |
| 10 | 9. 11 | 37. 35 | 68. 21 | 100. 53 | 132. 27 | 161. 32 |
| 11 | 10. 7 | 38. 34 | 69. 25 | 101. 58 | 133. 28 | 162. 28 |
| 12 | 11. 2 | 39. 33 | 70. 30 | 103. 3 | 134. 28 | 163. 24 |
| 13 | 11. 57 | 40. 32 | 71. 34 | 104. 8 | 135. 28 | 164. 20 |
| 14 | 12. 53 | 41. 32 | 72. 38 | 105. 12 | 136. 28 | 165. 16 |
| 15 | 13. 49 | 42. 32 | 73. 43 | 106. 17 | 137. 28 | 166. 11 |
| 16 | 14. 44 | 43. 31 | 74. 48 | 107. 22 | 138. 28 | 167. 7 |
| 17 | 15. 40 | 44. 31 | 75. 52 | 108. 26 | 139. 28 | 168. 3 |
| 18 | 16. 36 | 45. 32 | 76. 57 | 109. 30 | 140. 27 | 168. 58 |
| 19 | 17. 32 | 46. 32 | 78. 2 | 110. 35 | 141. 26 | 169. 53 |
| 20 | 18. 28 | 47. 33 | 79. 7 | 111. 39 | 142. 25 | 170. 49 |
| 21 | 19. 24 | 48. 34 | 80. 12 | 112. 42 | 143. 24 | 171. 44 |
| 22 | 20. 20 | 49. 34 | 81. 17 | 113. 46 | 144. 22 | 172. 39 |
| 23 | 21. 16 | 50. 36 | 82. 23 | 114. 50 | 145. 21 | 173. 34 |
| 24 | 22. 13 | 51. 37 | 83. 28 | 115. 53 | 146. 19 | 174. 29 |
| 25 | 23. 9 | 52. 38 | 84. 33 | 116. 57 | 147. 17 | 175. 25 |
| 26 | 24. 6 | 53. 40 | 85. 38 | 118. 0 | 148. 15 | 176. 20 |
| 27 | 25. 3 | 54. 42 | 86. 44 | 119. 3 | 149. 13 | 177. 15 |
| 28 | 26. 0 | 55. 44 | 87. 49 | 120. 6 | 150. 11 | 178. 10 |
| 29 | 26. 57 | 56. 46 | 88. 55 | 121. 9 | 151. 8 | 179. 5 |
| 30 | 27. 54 | 57. 49 | 90. 0 | 122. 11 | 152. 6 | 180. 0 |

## Sequel of the Table of the right Aſcenſion of the Degrees of the Ecliptic.

| | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|
| ° | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ | ° ′ |
| 0 | 180. 0 | 207. 54 | 237. 49 | 270. 0 | 302. 11 | 332. 6 |
| 1 | 180. 55 | 208. 51 | 238. 51 | 271. 5 | 303. 14 | 333. 3 |
| 2 | 181. 50 | 209. 49 | 239. 54 | 272. 11 | 304. 16 | 334. 0 |
| 3 | 182. 45 | 210. 47 | 240. 57 | 273. 16 | 305. 18 | 334. 57 |
| 4 | 183. 40 | 211. 44 | 242. 0 | 274. 21 | 306. 20 | 335. 54 |
| 5 | 184. 35 | 212. 42 | 243. 3 | 275. 27 | 307. 21 | 336. 51 |
| 6 | 185. 30 | 213. 41 | 244. 6 | 276. 32 | 308. 23 | 337. 47 |
| 7 | 186. 25 | 214. 39 | 245. 10 | 277. 38 | 309. 24 | 338. 44 |
| 8 | 187. 21 | 215. 37 | 246. 14 | 278. 43 | 310. 26 | 339. 40 |
| 9 | 188. 16 | 216. 36 | 247. 17 | 279. 48 | 311. 27 | 340. 36 |
| 10 | 189. 11 | 217. 35 | 248. 21 | 280. 53 | 312. 27 | 341. 32 |
| 11 | 190. 6 | 218. 34 | 249. 25 | 281. 58 | 313. 28 | 342. 28 |
| 12 | 191. 2 | 219. 33 | 250. 30 | 283. 3 | 314. 28 | 343. 24 |
| 13 | 191. 57 | 220. 32 | 251. 34 | 284. 8 | 315. 29 | 344. 20 |
| 14 | 192. 53 | 221. 32 | 252. 38 | 285. 13 | 316. 29 | 345. 16 |
| 15 | 193. 48 | 222. 32 | 253. 43 | 286. 17 | 317. 28 | 346. 12 |
| 16 | 194. 44 | 223. 31 | 254. 48 | 287. 22 | 318. 28 | 347. 7 |
| 17 | 195. 40 | 224. 32 | 255. 52 | 288. 26 | 319. 27 | 348. 3 |
| 18 | 196. 36 | 225. 32 | 256. 57 | 289. 30 | 320. 27 | 348. 58 |
| 19 | 197. 31 | 226. 32 | 258. 2 | 290. 35 | 321. 26 | 349. 53 |
| 20 | 198. 27 | 227. 33 | 259. 7 | 291. 39 | 322. 25 | 350. 49 |
| 21 | 199. 24 | 228. 34 | 260. 12 | 292. 43 | 323. 24 | 351. 44 |
| 22 | 200. 20 | 229. 35 | 261. 17 | 293. 46 | 324. 23 | 352. 39 |
| 23 | 201. 16 | 230. 36 | 262. 23 | 294. 50 | 325. 21 | 353. 34 |
| 24 | 202. 13 | 231. 37 | 263. 28 | 295. 54 | 326. 19 | 354. 30 |
| 25 | 203. 9 | 232. 38 | 264. 33 | 296. 57 | 327. 17 | 355. 25 |
| 26 | 204. 6 | 233. 40 | 265. 38 | 298. 0 | 328. 15 | 356. 20 |
| 27 | 205. 3 | 234. 42 | 266. 44 | 299. 3 | 329. 13 | 357. 15 |
| 28 | 206. 0 | 235. 44 | 267. 49 | 300. 6 | 330. 11 | 358. 10 |
| 29 | 206. 57 | 236. 46 | 268. 55 | 301. 9 | 331. 8 | 359. 5 |
| 30 | 207. 54 | 237. 49 | 270. 0 | 302. 11 | 332. 6 | 360. 0 |

# A TABLE

Containing the Longitudes of Places that have been determined by Aſtronomical Obſervations, reckoned from the Meridian of the Royal Obſervatory at *Greenwich*; and alſo their Latitudes.

| Names of Places. | Continent. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | H. | M. | S. |
| Abbeville | Eur. | France | Picardy | 50 | 7 | 1 | N | 1 | 49 | 45 | E | 0 | 7 | 19 |
| Abo | Eur. | Finland | Baltic Sea | 60 | 27 | 10 | N | 22 | 13 | 30 | E | 1 | 28 | 54 |
| Achem | Aſ. | N. W. Pt. Iſl. Sumatra | Indian Ocean | 5 | 22 | | N | 95 | 34 | | E | 6 | 22 | 16 |
| Agra | Aſ. | India | Moguls | 26 | 43 | 0 | N | 76 | 44 | 0 | E | 5 | 6 | 56 |
| Aix | Eur. | France | Provence | 43 | 31 | 35 | N | 5 | 26 | 15 | E | 0 | 21 | 45 |
| Alby | Eur. | France | Languedoc | 43 | 55 | 44 | N | 2 | 31 | 15 | E | 0 | 10 | 5 |
| Alexandretta | Aſ. | Syria | Mediter. Sea | 36 | 35 | 10 | N | 36 | 20 | 0 | E | 2 | 25 | 20 |
| Alexandria | Aſ. | Ægypt | Mediter. Sea | 31 | 11 | 20 | N | 30 | 16 | 30 | E | 2 | 1 | 6 |
| Amiens | Eur. | France | Picardy | 49 | 53 | 38 | N | 2 | 18 | 0 | E | 0 | 9 | 12 |
| Ancona | Eur. | Italy | Mediter. Sea | 43 | 37 | 54 | N | 13 | 30 | 30 | E | 0 | 54 | 2 |
| Angers | Eur. | France | Orleanois | 47 | 28 | 8 | N | 0 | 33 | 45 | W | 0 | 2 | 15 |
| Angoulême | Eur. | France | Orleanois | 45 | 39 | 3 | N | 0 | 8 | 45 | E | 0 | 0 | 35 |
| Antibes | Eur. | France | Mediter. Sea | 43 | 34 | 50 | N | 7 | 8 | 30 | E | 0 | 28 | 34 |
| Antwerp | Eur. | Flanders | River Scheld | 51 | 13 | 15 | N | 4 | 24 | 15 | E | 0 | 17 | 37 |
| Archangel | Eur. | Ruſſia | White Sea | 64 | 34 | 0 | N | 38 | 5 | 50 | E | 2 | 35 | 40 |
| Arica | Am. | Peru | South Sea | 18 | 26 | 38 | S | 71 | 11 | 0 | W | 4 | 44 | 44 |
| Arles | Eur. | France | Provence | 43 | 40 | 33 | N | 4 | 38 | 0 | E | 0 | 18 | 32 |
| Iſl. of Aſcenſion | Aſ. | Angola | S. Atl. Ocean | 7 | 57 | 0 | S | 13 | 59 | 0 | W | 0 | 55 | 56 |
| Athens | Eur. | Turkey | Archipelago | 38 | 5 | 0 | N | 23 | 52 | 30 | E | 1 | 35 | 30 |
| Auch | Eur. | France | Gaſcony | 43 | 38 | 46 | N | 0 | 30 | 0 | E | 0 | 2 | 0 |
| Aurillac | Eur. | France | Lionois | 44 | 55 | 10 | N | 2 | 27 | 0 | E | 0 | 9 | 48 |
| Auxerre | Eur. | France | Burgundy | 47 | 47 | 54 | N | 3 | 34 | 15 | E | 0 | 14 | 17 |
| Avignon | Eur. | France | Provence | 43 | 57 | 25 | N | 4 | 48 | 30 | E | 0 | 19 | 14 |
| Avranches | Eur. | France | Normandy | 48 | 41 | 18 | N | 1 | 22 | 45 | W | 0 | 5 | 31 |
| Antie. Babylon | Aſ. | Meſopotamia | Riv. Euphrates | 33 | 0 | 0 | N | 42 | 46 | 30 | E | 2 | 51 | 6 |
| Bagdad | Aſ. | Meſopotamia | | 33 | 21 | 0 | N | 43 | 46 | 30 | E | 2 | 55 | 6 |
| Balaſore | Aſ. | India | Bay Bengal | 21 | 20 | 0 | N | 86 | 0 | 0 | E | 5 | 44 | 0 |
| Bayeux | Eur. | France | Normandy | 49 | 16 | 30 | N | 0 | 42 | 45 | W | 0 | 2 | 51 |
| Bayonne | Eur. | France | Bay Biſcay | 43 | 29 | 21 | N | 1 | 30 | 0 | W | 0 | 6 | 0 |
| Great Bear Iſl. | Am. | | Hudſon's Bay | 54 | 34 | | N | 79 | 56 | 0 | W | 5 | 19 | 44 |
| Beavais | Eur. | France | Iſl. of France | 49 | 26 | 2 | N | 2 | 4 | 45 | E | 0 | 8 | 19 |
| Berlin | Eur. | Germany | River Elbe | 52 | 32 | 30 | N | 13 | 26 | 15 | E | 0 | 53 | 45 |
| Beſancon | Eur. | France | France Compte | 47 | 13 | 45 | N | 6 | 2 | 30 | E | 0 | 24 | 10 |
| Beziers | Eur. | France | Languedoc | 43 | 20 | 41 | N | 3 | 12 | 30 | E | 0 | 12 | 50 |
| Cape Blanco | Am. | Patagonia | Atl. Ocean | 47 | 20 | | S | 70 | 5 | 0 | W | 4 | 40 | 20 |

| Names of Places. | Con-tine. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | H. | M. | S. |
| Bologna S. Petr. | Eur. | Italy | Romania | 44 | 29 | 36 | N | 11 | 21 | 15 | E | 0 | 45 | 25 |
| Boſton | Am. | New England | Atl. Ocean | 42 | 25 | 0 | N | 70 | 37 | 15 | W | 4 | 42 | 29 |
| Boulogne | Eur. | France | Eng. Channel | 50 | 43 | 31 | N | 1 | 36 | 45 | E | 0 | 6 | 27 |
| Iſl. of Bourbon St. Dennis | Aſ. | Madagaſcar | Ind. Ocean | 20 | 51 | 43 | S | 55 | 30 | 0 | E | 3 | 42 | 0 |
| Bourdeaux | Eur. | France | River Garonne | 44 | 50 | 18 | N | 0 | 34 | 45 | W | 0 | 2 | 19 |
| Breſlaw | Eur. | Sileſia | River Oder | 51 | 3 | 0 | N | 17 | 8 | 45 | E | 1 | 8 | 35 |
| Breſt | Eur. | France | Atl. Ocean | 48 | 23 | 0 | N | 4 | 30 | 45 | W | 0 | 18 | 3 |
| St. Brieux | Eur. | France | Eng. Channel | 48 | 31 | 21 | N | 2 | 43 | 15 | W | 0 | 10 | 53 |
| Bruſſels | Eur. | Netherlands | Brabant | 50 | 51 | 0 | N | 4 | 21 | 45 | E | 0 | 17 | 27 |
| Buenos Ayres | Am. | Braſil | Atl. Ocean | 34 | 35 | 26 | S | 58 | 31 | 15 | W | 3 | 54 | 5 |
| Porto Cabello | Am. | Terra Firma | Caracos | 10 | 30 | 50 | N | 67 | 32 | 0 | W | 4 | 30 | 8 |
| Cadiz | Eur. | Spain | Atl. Ocean | 36 | 31 | 7 | N | 6 | 1 | 15 | W | 0 | 24 | 5 |
| Caen | Eur. | France | Eng. Channel | 49 | 11 | 10 | N | 0 | 21 | 45 | W | 0 | 1 | 27 |
| Cairo | Aſ. | Ægypt | River Nile | 30 | 2 | 30 | N | 31 | 26 | 15 | E | 2 | 5 | 45 |
| Cajaneburg | Eur. | Sweden | Finland | 64 | 13 | 30 | N | 27 | 43 | 15 | E | 1 | 50 | 53 |
| Calais | Eur. | France | Eng. Channel | 50 | 57 | 31 | N | 1 | 51 | 0 | E | 0 | 7 | 24 |
| F. Wil. Calcutta | Aſ. | India | Bengal | 22 | 36 | | N | 88 | 25 | 45 | E | 5 | 53 | 43 |
| Callao | Am. | Peru | South Sea | 12 | 1 | 53 | S | 76 | 58 | 0 | W | 5 | 7 | 52 |
| Calmar | Eur. | Sweden | Baltic Sea | 56 | 40 | 30 | N | 16 | 21 | 45 | E | 1 | 5 | 27 |
| Cambray | Eur. | Netherlands | Cambreſis | 50 | 10 | 30 | N | 3 | 13 | 45 | E | 0 | 12 | 55 |
| Cambridge | Eur. | England | Cambridge-ſhi. | 52 | 17 | | N | 0 | 5 | 45 | E | 0 | 0 | 23 |
| Iſl. of Candia | Eur. | Turkey | Medit. Sea | 35 | 18 | 35 | N | 25 | 18 | 0 | E | 1 | 41 | 12 |
| Canton | Aſ. | China | South Ocean | 23 | 7 | 30 | N | 113 | 2 | 0 | E | 7 | 32 | 8 |
| Carleſcroon | Eur. | Sweden | Baltic Sea | 56 | 20 | | N | 15 | 26 | 15 | E | 1 | 1 | 45 |
| Carthagena | Am. | Terra Firma | Carib. Sea | 10 | 26 | 35 | N | 75 | 26 | 15 | W | 5 | 1 | 45 |
| Caſan | Eur. | Ruſſia | Caſan | 55 | 44 | | N | 49 | 30 | 0 | E | 3 | 18 | 0 |
| Caſtres | Eur. | France | Languedoc | 43 | 37 | 10 | N | 2 | 14 | 45 | E | 0 | 8 | 59 |
| St. Catherine Iſ. | Am. | Plata | Atl. Ocean | 27 | 35 | | S | 49 | 17 | | W | 3 | 17 | 8 |
| Cayenne | Am. | Iſl. Cayenne | Atl. Ocean | 4 | 56 | 0 | N | 52 | 15 | 0 | W | 3 | 29 | 0 |
| Châlons | Eur. | France | River Marne | 48 | 57 | 12 | N | 4 | 22 | 15 | E | 0 | 17 | 29 |
| Challon | Eur. | France | River Saone | 46 | 46 | 50 | N | 4 | 51 | 30 | E | 0 | 19 | 26 |
| Chandernagor | Aſ. | India | Bengal | 22 | 51 | 26 | N | 88 | 29 | 15 | E | 5 | 53 | 57 |
| Charlton Iſland | Am. | New Wales | Hudſon's Bay | 52 | 3 | | N | 80 | 10 | | W | 5 | 20 | 40 |
| Chartres | Eur. | France | Orleanois | 48 | 26 | 49 | N | 1 | 29 | 0 | E | 0 | 5 | 56 |
| Cherburg | Eur. | France | Eng. Channel | 49 | 38 | 26 | N | 1 | 38 | 15 | W | 0 | 6 | 33 |
| Churchill River Pr. Wales Ft. | Am. | New Wales | Hudſon's Bay | 58 | 56 | | N | 94 | 55 | | W | 6 | 19 | 40 |
| Civita Vechia | Eur. | Italy | Mediter. Sea | 42 | 5 | 24 | N | 11 | 46 | 15 | E | 0 | 47 | 5 |
| Cape Clear | Eur. | Ireland | Weſt Ocean | 51 | 18 | | N | 11 | 15 | 0 | W | 0 | 45 | 0 |
| Clermont | Eur. | France | Lionois | 45 | 46 | 45 | N | 3 | 5 | 0 | E | 0 | 12 | 20 |
| Cape Comorin | Aſ. | India | Ind. Ocean | 7 | 56 | | N | 78 | 5 | | E | 5 | 12 | 20 |

| Names of Places. | Con-tine. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | H. | M. | S. |
| Conception | Am. | Chili | South Sea | 36 | 42 | 53 | S | 72 | 40 | 0 | W | 4 | 50 | 40 |
| Iſl. Pulo Condor | Af. | Gulf Siam | Ind. Ocean | 8 | 40 | | N | 107 | 20 | | E | 7 | 9 | 20 |
| Conſtantinople | Eur. | Turkey | Archipelago | 41 | 0 | 0 | N | 28 | 53 | 30 | E | 1 | 55 | 34 |
| Copenhagen | Eur. | Denmark | Baltic Sea | 55 | 40 | 45 | N | 12 | 45 | 15 | E | 0 | 51 | 1 |
| Coquimbo | Am. | Chili | South Ocean | 29 | 54 | 26 | S | 71 | 15 | 45 | W | 4 | 45 | 3 |
| Coutances | Eur. | France | Eng. Channel | 49 | 2 | 50 | N | 1 | 27 | 30 | W | 0 | 5 | 50 |
| Iſl. of Cummin | Af. | China | China Ocean | 31 | 40 | 0 | N | 121 | 4 | | E | 8 | 4 | 16 |
| Dantzic | Eur. | Poland | Baltic Sea | 54 | 22 | 0 | N | 18 | 31 | | E | 1 | 14 | 4 |
| Dax | Eur. | France | River Adour | 43 | 42 | 23 | N | 1 | 4 | | W | 0 | 4 | 16 |
| Dieppe | Eur. | France | Eng. Channel | 49 | 55 | 17 | N | 1 | 4 | 15 | E | 0 | 4 | 17 |
| Dijon | Eur. | France | Burgundy | 47 | 19 | 22 | N | 5 | 2 | 30 | E | 0 | 20 | 10 |
| Dol | Eur. | France | Britany | 48 | 33 | 9 | N | 1 | 46 | 15 | W | 0 | 7 | 5 |
| Drontheim | Eur. | Norway | North Ocean | 63 | 26 | 10 | N | 11 | 3 | 45 | E | 0 | 44 | 15 |
| Dunkirk | Eur. | France | Eng. Channel | 51 | 2 | 4 | N | 2 | 22 | 30 | E | 0 | 9 | 30 |
| Edinburgh | Eur. | Scotland | German Ocean | 55 | 57 | 57 | N | 3 | 18 | 16 | W | 0 | 13 | 13 |
| Embrun | Eur. | France | Dauphiny | 44 | 34 | 0 | N | 6 | 29 | 0 | E | 0 | 25 | 56 |
| Erzerom | Af. | Armenia | | 39 | 56 | 35 | N | 48 | 35 | 45 | E | 3 | 14 | 23 |
| Evereux | Eur. | France | Normandy | 49 | 1 | 24 | N | 1 | 8 | 45 | E | 0 | 4 | 35 |
| Exeter | Eur. | England | Devonſhire | 50 | 44 | | N | 3 | 34 | 30 | W | 0 | 14 | 18 |
| Falmouth | Eur. | England | Eng. Channel | 50 | 8 | | N | 5 | 28 | 20 | W | 0 | 21 | 53 |
| Ferrara | Eur. | Italy | River Po | 44 | 54 | 0 | N | 11 | 36 | 15 | E | 0 | 46 | 25 |
| Iſl. of Ferro, at the Town | Af. | Canaries | Atl. Ocean | 27 | 47 | 20 | N | 17 | 33 | 45 | W | 1 | 10 | 15 |
| Florence | Eur. | Italy | River Arno | 43 | 46 | 30 | N | 11 | 2 | 0 | E | 0 | 44 | 8 |
| St. Flour | Eur. | France | Lionois | 45 | 1 | 55 | N | 3 | 5 | 30 | E | 0 | 12 | 22 |
| Ca. St. François | Am. | Hiſpaniola | Atl. Ocean | 19 | 40 | | N | 71 | 40 | | W | 4 | 46 | 40 |
| Frawenburgh | Eur. | Pruſſia | Baltic Sea | 54 | 22 | 15 | N | 20 | 7 | 30 | E | 1 | 20 | 30 |
| Frejus | Eur. | France | Mediter. Sea | 43 | 26 | 3 | N | 6 | 44 | 45 | E | 0 | 26 | 59 |
| Strs. of Fronſac, narroweſt Part oppoſ. a high Mountain towards the Continent | Am. | Nova Scotia | Iſl. Cape Breton | 45 | 39 | | N | 61 | 20 | | W | 4 | 5 | 20 |
| Geneva | Eur. | Savoy | River Rhone | 46 | 12 | 0 | N | 6 | 35 | 0 | E | 0 | 26 | 20 |
| Genoa | Eur. | Italy | Mediter. Sea | 44 | 25 | 0 | N | 8 | 35 | 45 | E | 0 | 34 | 23 |
| Fort St. George | Af. | India | Bay Bengal | 13 | 13 | | N | 80 | 2 | 15 | E | 5 | 20 | 9 |
| Ghent | Eur. | Netherlands | Flanders | 51 | 3 | 0 | N | 3 | 43 | 45 | E | 0 | 14 | 55 |
| Goa | Af. | India | Arab. Sea | 15 | 31 | 0 | N | 73 | 45 | 0 | E | 4 | 55 | 0 |
| Ca. Good-Hope | Af. | Caffers | Indian Ocean | 33 | 55 | 42 | S | 18 | 23 | 15 | E | 1 | 13 | 33 |
| Gottenburg | Eur. | Sweden | Sound | 57 | 42 | 0 | N | 11 | 38 | 45 | E | 0 | 46 | 35 |
| Gottingen, Obſ. | Eur. | Germany | Brunſwic | 51 | 31 | 54 | N | 9 | 54 | 0 | E | 0 | 39 | 36 |
| Granville | Eur. | France | Eng. Channel | 48 | 50 | 11 | N | 1 | 37 | 0 | W | 0 | 6 | 28 |
| Graſſe | Eur. | France | Provence | 43 | 39 | 25 | N | 6 | 56 | 0 | E | 0 | 27 | 44 |
| R. Obſ. Greenw. | Eur. | England | Kent | 51 | 28 | 40 | N | 0 | 0 | 0 | | 0 | 0 | 0 |
| Grenoble | Eur. | France | Dauphine | 45 | 11 | 49 | N | 5 | 43 | 0 | E | 0 | 22 | 52 |

| Names of Places. | Con-tine. | Country. | Coaſt or Province. | Latitude. | | | Longitude. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | In Degrees. | | | In Time. | | |
| | | | | ° | ′ | ″ | ° | ′ | ″ | H. | M. | S. |
| Guaquil | Am. | Peru | South Sea | 2 | 11 | 21 S | 81 | 11 | 30 W | 5 | 24 | 46 |
| Hague | Eur. | Netherlands | Holland | 52 | 4 | 10 N | 4 | 17 | 30 E | 0 | 17 | 10 |
| Havanna | Am. | Iſl. Cuba | Atl. Ocean | 23 | 11 | 52 N | 82 | 18 | 30 W | 5 | 29 | 14 |
| Iſl. St. Helena, James's Fort | Af. | Benguela | Atl. Ocean | 15 | 55 | S | 5 | 49 | 0 W | 0 | 23 | 16 |
| Hernoſand | Eur. | Sweden | Gulf Bothnia | 62 | 38 | N | 17 | 53 | 0 E | 1 | 11 | 32 |
| Hoai-Nghan | Aſ. | China | Kyangnan | 33 | 34 | 40 N | 118 | 49 | 30 E | 7 | 55 | 18 |
| Port Royal, Iſl. of Jamaica | Am. | Weſt Indies | Atl. Ocean | 18 | 0 | N | 76 | 45 | 30 W | 5 | 7 | 2 |
| Rio Janeiro | Am. | Braſil | Atl. Ocean | 22 | 54 | 10 S | 42 | 45 | 0 W | 2 | 51 | 0 |
| Jeruſalem | Aſ. | Paleſtine | Inland | 31 | 55 | 0 N | 35 | 20 | 0 E | 2 | 21 | 20 |
| Ingolſtadt | Eur. | Germany | River Danube | 48 | 46 | 0 N | 11 | 22 | 30 E | 0 | 45 | 30 |
| St. John's Fort | Am. | Newfoundland | Atl. Ocean | 47 | 32 | N | 52 | 48 | 15 W | 3 | 31 | 13 |
| Iſlamabad | Aſ. | India | | 22 | 20 | N | 91 | 45 | E | 6 | 7 | 0 |
| Port St. Julian | Am. | Patagonia | S. Atl. Ocean | 49 | 10 | N | 68 | 44 | W | 4 | 34 | 56 |
| Juthia | Aſ. | India | Capit. Siam | 14 | 18 | N | 100 | 50 | 0 E | 6 | 43 | 20 |
| Landau | Eur. | Germany | Alſace | 49 | 11 | 40 N | 8 | 7 | 30 E | 0 | 32 | 30 |
| Landſcroon | Eur. | Sweden | Sound | 55 | 52 | N | 12 | 46 | 45 E | 0 | 51 | 7 |
| Lauſance | Eur. | Switzerland | Lake Geneva | 46 | 31 | 5 N | 6 | 45 | 15 E | 0 | 27 | 1 |
| Lectoure | Eur. | France | Gaſcony | 43 | 56 | 2 N | 0 | 37 | 0 E | 0 | 2 | 28 |
| Leipſic | Eur. | Germany | Saxony | 51 | 19 | 14 N | 12 | 20 | 0 E | 0 | 49 | 20 |
| Leſkeard | Eur. | England | Cornwall | 50 | 26 | 55 N | 4 | 41 | 45 W | 0 | 18 | 47 |
| Leyden | Eur. | Netherlands | Holland | 52 | 10 | N | 4 | 27 | 30 E | 0 | 17 | 50 |
| Liſle | Eur. | Netherlands | | 50 | 37 | 50 N | 3 | 4 | 15 E | 0 | 12 | 17 |
| Lima | Am. | Peru | South Sea | 12 | 1 | 15 S | 76 | 49 | 30 W | 5 | 7 | 18 |
| Liſbon, Congr. Orator | Eur. | Portugal | River Tagus | 38 | 42 | 20 N | 9 | 7 | 30 W | 0 | 36 | 30 |
| Lizard | Eur. | England | Eng. Channel | 49 | 57 | N | 5 | 43 | W | 0 | 22 | 52 |
| London, at St. Paul's | Eur. | England | Middleſex | 51 | 30 | 40 N | 0 | 5 | 37 W | 0 | 0 | 22½ |
| Cape Lorenſo | Am. | Peru | South Sea | 1 | 2 | S | 80 | 17 | W | 5 | 21 | 8 |
| Port St. Louis | Am. | Hiſpaniola | Atl. Ocean | 18 | 19 | 0 N | 73 | 6 | 0 W | 4 | 52 | 24 |
| Louiſbourg | Am. | Cape Breton | Atl. Ocean | 45 | 53 | 45 N | 59 | 55 | 0 W | 3 | 59 | 40 |
| Louveau | Aſ. | India | Kingd. Siam | 12 | 42 | 30 | 101 | 1 | 30 E | 6 | 44 | 6 |
| Lucon | Eur. | France | Orleanois | 46 | 27 | 14 N | 1 | 10 | 30 W | 0 | 4 | 42 |
| Lunden | Eur. | Sweden | Schonen | 55 | 41 | 36 N | 13 | 21 | 15 E | 0 | 53 | 25 |
| Lyons | Eur. | France | Lionois | 45 | 45 | 51 N | 4 | 49 | 45 E | 0 | 19 | 19 |
| Macao | Aſ. | China | South Ocean | 22 | 12 | 44 N | 113 | 46 | 15 E | 7 | 35 | 5 |
| Madrid | Eur. | Spain | New Caſtile | 40 | 25 | 0 N | 3 | 44 | 30 W | 0 | 14 | 58 |
| Port Mahon, FortSt.Philips | Eur. | Iſl. Minorca | Mediter. Sea | 39 | 50 | 46 N | 3 | 48 | 30 E | 0 | 15 | 14 |
| Malaca | Aſ. | India | Straits Malacca | 2 | 12 | 6 N | 102 | 5 | 0 E | 6 | 48 | 20 |
| Malines | Eur. | Netherlands | | 51 | 1 | 50 N | 4 | 28 | 45 E | 0 | 17 | 55 |
| St. Malo | Eur. | France | Eng. Channel | 48 | 38 | 59 N | 2 | 2 | 15 W | 0 | 8 | 9 |
| Iſl. Malta | Eur. | Italy | Mediter. Sea | 35 | 54 | 0 N | 14 | 28 | 30 E | 0 | 57 | 54 |

| Names of Places. | Con-tine. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | ° | ′ | ″ |
| Manila | Af. | Iſl. Manila | South Ocean | 14 | 30 | | N | 120 | 20 | | E | 8 | 1 | 20 |
| Marſeilles | Eur. | France | Mediter. Sea | 43 | 17 | 45 | N | 5 | 22 | 15 | E | 0 | 21 | 29 |
| St. Martha | Am. | Terra Firma | Caribean Sea | 11 | 26 | 40 | N | 74 | 4 | 30 | W | 4 | 56 | 18 |
| Martinico, St. Peter's Fort | Am. | Weſt Indies | Atl. Ocean | 14 | 44 | | N | 61 | 21 | 16 | W | 4 | 5 | 25 |
| Iſl. Mauritius, Port Louis | Am. | Madagaſcar | Indian Ocean | 20 | 9 | 45 | S | 57 | 28 | 0 | E | 3 | 49 | 52 |
| Meaux | Eur. | France | Champaigne | 48 | 57 | 37 | N | 2 | 52 | 30 | E | 0 | 11 | 30 |
| Mergui | Af. | India | Kingdom Siam | | | | | 98 | 8 | 45 | E | 6 | 32 | 35 |
| Metz | Eur. | France | Lorrain | 49 | 7 | 5 | N | 6 | 11 | 0 | E | 0 | 24 | 44 |
| Mexico | Am. | Mexico | Inland | 20 | 0 | 0 | N | 103 | 40 | 0 | W | 6 | 54 | 40 |
| Modena | Eur. | Italy | Modena | 44 | 34 | 0 | N | 11 | 12 | 30 | E | 0 | 44 | 50 |
| Mons | Eur. | Netherlands | | 50 | 27 | 10 | N | 3 | 57 | 15 | E | 0 | 15 | 49 |
| Montpellier | Eur. | France | Languedoc | 43 | 36 | 33 | N | 3 | 52 | 45 | E | 0 | 15 | 31 |
| Moſcow | Eur. | Ruſſia | Moſcow | 55 | 45 | 20 | N | 37 | 46 | 15 | E | 2 | 31 | 5 |
| Moulins | Eur. | France | Lionois | 46 | 34 | 4 | N | 3 | 20 | 0 | E | 0 | 13 | 20 |
| Nancy | Eur. | France | Lorrain | 48 | 41 | 28 | N | 6 | 11 | 30 | E | 0 | 24 | 46 |
| Nangaſachi | Af. | Capital Japan | South Sea | 32 | 32 | | N | 128 | 46 | 15 | E | 8 | 35 | 5 |
| Nants | Eur. | France | River Loire | 47 | 13 | 17 | N | 1 | 33 | 45 | W | 0 | 6 | 15 |
| Naples, Royal College | Eur. | Italy | Mediter. Sea | 40 | 50 | 45 | N | 14 | 13 | 45 | E | 0 | 56 | 55 |
| Narbonne | Eur. | France | Mediter. Sea | 43 | 11 | 13 | N | 3 | 0 | 15 | E | 0 | 12 | 1 |
| Nice | Eur. | France | Medit. Sea | 43 | 41 | 54 | N | 7 | 17 | 15 | E | 0 | 29 | 9 |
| Nieuport | Eur. | Flanders | German Ocean | 51 | 7 | 41 | N | 2 | 45 | 0 | E | 0 | 11 | 0 |
| Ningpo | Af. | China | South Sea | 29 | 57 | 45 | N | 120 | 18 | 0 | E | 8 | 1 | 12 |
| Niſmes | Eur. | France | Languedoc | 43 | 50 | 35 | N | 4 | 21 | 15 | E | 0 | 17 | 25 |
| Noyon | Eur. | France | Iſ. of France | 49 | 34 | 37 | N | 3 | 0 | 45 | E | 0 | 12 | 3 |
| Nuremberg | Eur. | Germany | Franconia | 49 | 26 | 55 | N | 11 | 4 | 0 | E | 0 | 44 | 16 |
| Olinde | Am. | Braſil | S. Atl. Ocean | 8 | 13 | 0 | N | 35 | 1 | 0 | W | 2 | 20 | 4 |
| St. Omer's | Eur. | Netherlands | Flanders | 50 | 44 | 46 | N | 2 | 15 | 0 | E | 0 | 9 | 0 |
| Orleans | Eur. | France | Orleanois | 47 | 54 | 4 | N | 1 | 54 | 15 | W | 0 | 7 | 37 |
| New Orleans | Am. | Louiſiana | Riv. Miſſiſſippi | 29 | 57 | 45 | N | 89 | 58 | 45 | W | 5 | 59 | 55 |
| Oſtend | Eur. | Flanders | German Ocean | 51 | 13 | 55 | N | 2 | 55 | 0 | E | 0 | 11 | 40 |
| Oxford | Eur. | England | Oxfordſhire | 51 | 45 | 0 | N | 1 | 16 | 0 | W | 0 | 5 | 4 |
| Padua | Eur. | Italy | Venice | 45 | 22 | 26 | N | 11 | 55 | 30 | E | 0 | 47 | 42 |
| Panama | Am. | Mexico | South Ocean | 8 | 57 | 48 | N | 80 | 21 | | W | 5 | 21 | 24 |
| Paris, Obſerva. | Eur. | France | Iſ. of France | 48 | 50 | 14 | N | 2 | 20 | 0 | E | 0 | 9 | 20 |
| Pau | Eur. | Switzerland | Bearn | 43 | 15 | 0 | N | 0 | 9 | 0 | W | 0 | 0 | 36 |
| St. Paul de Leon | Eur. | France | Eng. Channel | 48 | 40 | 55 | N | 4 | 0 | 15 | W | 0 | 16 | 1 |
| Pekin | Af. | China | Inland | 39 | 54 | 0 | N | 116 | 22 | 30 | E | 7 | 45 | 30 |
| Perinaldi | Eur. | Italy | Medit. Sea | 43 | 53 | 20 | N | 7 | 40 | 0 | E | 0 | 30 | 40 |
| Perpignan | Eur. | France | Rouſſillon | 42 | 41 | 55 | N | 2 | 54 | 0 | E | 0 | 11 | 36 |
| St. Peterſbourg | Eur. | Ruſſia | Baltic Sea | 59 | 56 | 0 | N | 30 | 20 | 0 | E | 2 | 1 | 20 |

| Names of Places. | Continent. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | H. | M. | S. |
| Petit-Goave | Am. | Iſ. Hiſpaniola | Atl. Ocean | 18 | 27 | | N | 72 | 33 | 45 | W | 4 | 50 | 15 |
| Plimouth Town | Eur. | England | Devonſhire | 50 | 26 | | N | 4 | 18 | 51 | W | 0 | 17 | 15 |
| Do. Ram-Head | | | | 50 | 23 | | N | 4 | 22 | 25 | W | 0 | 17 | 30 |
| Do. Edyſtone | | | | 50 | 12 | | N | 4 | 25 | 58 | W | 0 | 17 | 44 |
| Pondicherry | Aſ. | India | Bay Bengal | 11 | 56 | 30 | N | 75 | 7 | 30 | E | 5 | 0 | 30 |
| Porto-Bello | Am. | New Spain | Carib. Sea | 9 | 33 | 5 | N | 79 | 50 | 0 | W | 5 | 19 | 20 |
| Portſmouth | Eur. | England | Eng. Channel | 50 | 49 | | N | 1 | 5 | | W | 0 | 4 | 20 |
| Prague | Eur. | Bohemia | | 50 | 4 | 30 | N | 14 | 45 | 0 | E | 0 | 59 | 0 |
| Iſ. of Pulicondor | Aſ. | Gulf of Siam | Ind. Ocean | 8 | 40 | | N | 107 | 20 | | E | 7 | 9 | 20 |
| Quebec | Am. | Canada | Riv. S. Laurence | 46 | 55 | 0 | N | 69 | 53 | 0 | W | 4 | 39 | 32 |
| Quito | Am. | Peru | Inland | 0 | 13 | 17 | S | 77 | 55 | 0 | W | 5 | 11 | 40 |
| Antient Rakah | Aſ. | Meſopotamia | Riv. Euphrates | 36 | 1 | | N | 38 | 50 | 0 | E | 2 | 35 | 20 |
| Reims | Eur. | France | Champaigne | 49 | 14 | 36 | N | 4 | 3 | 0 | E | 0 | 16 | 12 |
| Rennes | Eur. | France | Britany | 48 | 6 | 45 | N | 1 | 42 | 0 | W | 0 | 6 | 48 |
| Rimini | Eur. | Italy | Adr. Sea | 44 | 3 | 43 | N | 12 | 34 | 15 | E | 0 | 50 | 17 |
| Rhodes | Eur. | France | Guienne | 44 | 21 | 0 | N | 2 | 34 | 15 | E | 0 | 10 | 17 |
| Rochelle | Eur. | France | Bay Biſcay | 46 | 9 | 43 | N | 1 | 15 | 45 | W | 0 | 5 | 3 |
| Rodrigues | Aſ. | Madagaſcar | Indian Ocean | 19 | 40 | 40 | S | 63 | 10 | 0 | E | 4 | 12 | 40 |
| Rome, S. Peter's | Eur. | Italy | River Tiber | 41 | 53 | 54 | N | 12 | 29 | 15 | E | 0 | 49 | 57 |
| Rotterdam | Eur. | Holland | German Ocean | 51 | 56 | 0 | N | 4 | 28 | 15 | E | 0 | 17 | 53 |
| Rouen | Eur. | France | River Seyne | 49 | 26 | 43 | N | 1 | 5 | 15 | E | 0 | 4 | 21 |
| Cape Sable | Am. | New Scotland | Atl. Ocean | 43 | 24 | 0 | N | 65 | 30 | | W | 4 | 22 | 0 |
| Salonique | Eur. | Turkey | Archipelago | 40 | 41 | 10 | N | 23 | 8 | 0 | E | 1 | 32 | 32 |
| Scilly Iſles, St. Agnes Light-houſe | Eur. | England | Eng. Channel | 49 | 56 | | N | 7 | 14 | | W | 0 | 28 | 56 |
| Seez | Eur. | France | Normandy | 48 | 36 | 21 | N | 0 | 9 | 45 | E | 0 | 0 | 39 |
| Sens | Eur. | France | Champaigne | 48 | 11 | 56 | N | 3 | 17 | 0 | E | 0 | 13 | 8 |
| Sherburne Caſt. | Eur. | England | Oxfordſhire | 51 | 39 | 25 | N | 1 | 0 | 0 | W | 0 | 4 | 0 |
| Si-nghan-fu | Aſ. | China | | 34 | 16 | 30 | N | 108 | 43 | 45 | E | 7 | 14 | 55 |
| Smyrna | Aſ. | Natolia | Archipelago | 38 | 28 | 7 | N | 27 | 19 | 45 | E | 1 | 49 | 1[illegible] |
| Soiſſons | Eur. | France | Iſl. of France | 49 | 22 | 32 | N | 3 | 19 | 30 | E | 0 | 13 | 18 |
| Stalbridge | Eur. | England | Devonſhire | 50 | 57 | | N | 2 | 23 | 30 | W | 0 | 9 | 3 |
| Start Point | Eur. | England | Eng. Channel | 50 | 9 | | N | 3 | 51 | 15 | W | 0 | 15 | 2[illegible] |
| Stockholm | Eur. | Sweden | Baltic Sea | 59 | 20 | 31 | N | 18 | 2 | 45 | E | 1 | 12 | 11 |
| Stratſburg | Eur. | Germany | Alſace | 48 | 34 | 35 | N | 7 | 46 | 15 | E | 0 | 31 | |
| Tarbes | Eur. | France | Gaſcony | 43 | 14 | 2 | N | 0 | 3 | 30 | E | 0 | 0 | 1 |
| Pic of Teneriff | Aſ. | Canaries | Atl. Ocean | 28 | 12 | 54 | N | 16 | 32 | 0 | W | 1 | 6 | |
| Iſ. of St. Thomas | Am. | Virgin Iſles | Atl. Ocean | 18 | 21 | 55 | N | 64 | 33 | 0 | W | 4 | 18 | [illegible] |
| Iſ. Pulo Timon | Aſ. | Gulf Siam | Ind. Ocean | 3 | 0 | | N | 104 | 25 | | E | 6 | 57 | |
| Tobolſki | Aſ. | Ruſſia | Siberia | 58 | 12 | 18 | N | 68 | 12 | 45 | E | 4 | 32 | |
| Tornea | Eur. | Sweden | Gulf Bothnia | 65 | 50 | 50 | N | 24 | 12 | 0 | E | 1 | 36 | |

| Names of Places. | Con-tine. | Country. | Coaſt or Province. | Latitude. | | | | Longitude. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | In Degrees. | | | | In Time. | | |
| | | | | ° | ′ | ″ | | ° | ′ | ″ | | H. | M. | S. |
| Toulon | Eur. | France | Mediter. Sea | 43 | 7 | 24 | N | 5 | 56 | 30 | E | 0 | 23 | 46 |
| Toulouſe | Eur. | France | Languedoc | 43 | 35 | 54 | N | 1 | 26 | 15 | E | 0 | 5 | 45 |
| Tours | Eur. | France | Orleanois | 47 | 23 | 44 | N | 0 | 41 | 15 | E | 0 | 2 | 45 |
| Tripoli | Af. | Barbary | Mediter. Sea | 32 | 53 | 40 | N | 13 | 5 | 15 | E | 0 | 52 | 21 |
| Turin | Eur. | Italy | River Po | 45 | 5 | 20 | N | 7 | 40 | 0 | E | 0 | 30 | 40 |
| Upſal | Eur. | Sweden | River Sala | 59 | 51 | 50 | N | 17 | 42 | 15 | E | 1 | 10 | 49 |
| Uraniberg | Eur. | Denmark | Baltic Sea | 55 | 54 | 15 | N | 12 | 52 | 30 | E | 0 | 51 | 30 |
| Valparais | Am. | Chili | South Sea | 33 | 2 | 36 | S | 72 | 19 | 15 | W | 4 | 49 | 17 |
| Venice | Eur. | Italy | Adriat. Sea | 45 | 25 | 0 | N | 12 | 4 | 30 | E | 0 | 48 | 18 |
| Vera Cruz | Am. | New Spain | Gulf Mexico | 19 | 12 | | N | 97 | 30 | | E | 6 | 30 | 0 |
| Verdun | Eur. | France | Lorrain | 49 | 9 | 18 | N | 5 | 22 | 45 | E | 0 | 21 | 31 |
| Verona | Eur. | Italy | Venice | 45 | 26 | 26 | N | 11 | 18 | 30 | E | 0 | 45 | 14 |
| Verſailles | Eur. | France | Iſ. of France | 48 | 48 | 18 | N | 2 | 7 | 15 | E | 0 | 8 | 29 |
| Cape Verd | Af. | Negroland | Atl. Ocean | 14 | 43 | 0 | N | 17 | 10 | 0 | W | 1 | 8 | 40 |
| Vienna, Imperial Obſerva. | Eur. | Germany | River Danube | 48 | 12 | 48 | N | 16 | 22 | 30 | E | 1 | 5 | 30 |
| Vintimiglia | Eur. | Italy | Mediter. Sea | 43 | 53 | 20 | N | 7 | 37 | 30 | E | 0 | 30 | 30 |
| Virgin Gorda Fort | Am. | Weſt Indies | Atl. Ocean | 18 | 18 | | N | 64 | 0 | | W | 4 | 16 | 0 |
| Cape Virgin's | Am. | Patagonia | Atl. Ocean | 52 | 26 | | N | 71 | 5 | | W | 4 | 44 | 20 |
| Wakefield | Eur. | England | Yorkſhire | 53 | 41 | | N | 1 | 33 | 30 | W | 0 | 6 | 14 |
| Wanſtead | Eur. | England | Eſſex | 51 | 34 | 0 | N | 0 | 2 | 30 | E | 0 | 0 | 10 |
| Wittenberg | Eur. | Germany | Saxony | 51 | 43 | 10 | N | 12 | 33 | 30 | E | 0 | 50 | 14 |
| Ylo | Am. | Peru | South Sea | 17 | 36 | 15 | S | 71 | 13 | 0 | W | 4 | 44 | 52 |
| York | Eur. | England | River Ouſe | 53 | 59 | | N | 1 | 6 | 40 | W | 0 | 4 | 27 |
| New York | Am. | New England | Atl. Ocean | 40 | 43 | | N | 74 | 9 | | W | 4 | 56 | 36 |

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